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International Joint Commission (U.S. and Canada) 1909-

Pollution of boundary waters. Conference with sanitary engineers at New York City, May 26 and 27, 1914.

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INTERNATIONAL JOINT COMMISSION (U.S. and Canada) 1909-

POLLUTION OF BOUNDARY WATERS

CONFERENCE WITH SANITARY ENGINEERS
AT NEW YORK CITY
MAY 26 AND 27, 1914

(REPRINTED BY ORDER OF THE COMMISSION)

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INTERNATIONAL JOINT COMMISSION.

CANADA.	UNITED STATES.
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HENRY A. POWELL, K. C.	OBADIAH GARDNER.
CHARLES A. MAGRATH.	R. B. GLENN.
LAWRENCE J. BURPEE, *Secretary.*	WHITEHEAD KLUTTZ, *Secretary.*

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INTERNATIONAL JOINT COMMISSION.

POLLUTION OF BOUNDARY WATERS.

CONFERENCE WITH SANITARY ENGINEERS AT NEW YORK CITY, MAY 26 AND 27, 1914.

New York, N. Y., *Tuesday, May 26, 1914.*

Present: James A. Tawney (presiding); Th. Chase Casgrain, K. C.; R. B. Glenn; Henry Powell, K. C.; Obadiah Gardner; Charles A. Magrath; Whitehead Kluttz, secretary; Lawrence J. Burpee, secretary.

There were also present: Mr. George W. Fuller, 170 Broadway, New York City; Mr. George C. Whipple, 30 East Forty-second Street, New York City; Mr. Earle B. Phelps, United States Public Health Service, Washington, D. C.; Mr. W. S. Lea, 802 New Birks Building, Montreal, Canada; Mr. T. J. Lafreniere, provincial board of health, Ninth and James Streets, Montreal, Canada; Mr. F. A. Dallyn, provincial board of health, Toronto, Canada; Dr. Allan J. McLaughlin, United States Public Health Service, Washington, D. C.; Dr. T. A. Starkey, McGill University, Montreal, Canada.

The Chairman. Gentlemen, for the purpose of making the record of this hearing complete, I desire to call your attention to the fact that under Article IV of the treaty between the United States and Great Britain, signed at Washington, January 11, 1909, the two Governments have expressely agreed as follows:

> It is further agreed that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other.

Complaints having been made to both Governments that that provision of the treaty was not being observed, the two Governments joined in referring to this commission, which was created by that treaty under Article IX thereof, two questions in the main. The first question is as follows:

> To what extent and by what causes and in what localities have the boundary waters between the United States and Canada been polluted so as to be injurious to the public health and not fit for domestic or other uses?

The second question of the reference reads as follows:

> In what way or manner, whether by the construction and operation of suitable drainage canals or plants at convenient points or otherwise is it possible and advisable to remedy or prevent the pollution of these waters, and by what means or arrangement can the proper construction or operation of remedial or preventive works, or a system or method of rendering these waters sanitary and suitable for domestic and other uses, be best secured and maintained in

order to insure the adequate protection and development of all interests involved on both sides of the boundary, and to fulfill the obligations undertaken in article 4 of the waterways treaty of January 11, 1909, between the United States and Great Britain, in which it is agreed that the waters therein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other?

I may say that under this reference the commission proceeded in 1913, through the aid of bacteriologists or sanitary experts on both sides of the line, with the investigation of the first question. Their report and a progress report of the commission was made last January. That report will be in print very soon. I understand that copies of the proof sheets have been presented to you gentlemen. The report of the sanitary experts shows as a fact that pollution does exist in these waters on both sides of the line and extends across the boundary. At Washington in April last the commission adopted a plan of procedure for the investigation of the second branch of this reference. That plan of procedure is as follows:

TENTATIVE PLAN FOR CONDUCT OF INVESTIGATION OF SECOND BRANCH OF REFERENCE IN RE POLLUTION OF BOUNDARY WATERS.

The terms of the treaty expressly provide that the commission has full and complete jurisdiction over the entire "Waters from main shore to main shore of the lakes and rivers and connecting waterways or the portions thereof along which the international boundary between the United States and Canada passes, including all bays, arms, and inlets thereof."

It was deemed advisable by the two Governments to confine the present inquiry, however, to cases of pollution of boundary waters on one side of the boundary which extend to and affect the boundary waters on the other side. This limitation of the investigation in no way nullifies the full and complete jurisdiction of this commission over all the waters through which the boundary line passes. While there can be no question of the jurisdiction of the commission over all parts of the boundary waters, it is necessary and advisable to deal with those portions of the boundary waters first in which serious pollution actually crosses the boundary. As the degree of pollution varies in these localities, so also the degree of treatment of the offending sewage must vary. The attention of the commission should be directed first to the following:

1. All communities on the St. Marys River, St. Clair River, Lake St. Clair, Detroit River, Niagara River, and St. Lawrence River above Cornwall, Ontario.
2. Communities on any of the Great Lakes which are situated within 25 miles of the outlet from the lake.
3. Municipalities on any of the Great Lakes which are situated within 25 miles of the international boundary, excepting municipalities with less than 10,000 population which are situated more than 15 miles from the international boundary.

The classes of municipalities or communities given above include those localities where pollution is greatest and where such pollution constitutes a problem or is likely to cause international controversy. In addition to these localities every municipality or community discharging sewage into the international boundary waters comes within the jurisdiction of the commission, and in order to maintain control over these and to provide for their future growth or contingencies which may arise it is necessary for the commission to recommend certain requirements of all municipalities or communities which pollute in any degree the international boundary waters.

All municipalities or communities discharging sewage or wastes of any kind into boundary waters through a sewer or system of sewerage should be required to file with the Federal authority charged with the protection of the public health in the United States or Canada, as the case may be, plans of their existing sewers or sewerage systems in quadruplicate, and if extensions or alterations are desired, application (with full description and plans in quadruplicate) should be made to the said Federal authority for permission. Until the application is favorably considered and the permit granted, work should not be commenced on the proposed extension or alteration.

The completion of the field work and the report of the sanitary experts thereon in the investigation of pollution of boundary waters enables the commission to answer the questions embraced in the first half of the reference, viz:

"1. To what extent and by what causes and in what localities have the boundary waters between the United States and Canada been polluted so as to be injurious to the public health and unfit for domestic or other uses?"

It now becomes the duty of the commission to proceed with the investigation of the questions in the second half of the reference, as follows:

"2. In what way or manner, whether by the construction and operation of suitable drainage canals or plants at convenient points or otherwise, is it possible and advisable to remedy or prevent the pollution of these waters, and by what means or arrangement can the proper construction or operation of remedial or preventive works, or a system or method of rendering these waters sanitary and suitable for domestic and other uses, be best secured and maintained in order to insure the adequate protection and development of all interests involved on both sides of the boundary and to fulfill the obligations undertaken in Article IV of the waterways treaty of January 11, 1909, between the United States and Great Britain, in which it is agreed that the waters therein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other?"

This portion of the reference specifically asks what measures are necessary to remedy or prevent the pollution of these boundary waters found to exist in contravention of the treaty.

To enable the commission to intelligently answer these questions and to insure a fair and equitable consideration of the interests of the States, Provinces, and municipalities involved, it would seem advisable to divide the work into four separate and distinct branches.

1. Securing opinions from leading sanitary engineers upon questions relating to general policy, and consultations with the sanitary engineers and sanitarians to be employed by the commission.

2. Hearings to enable all interested parties to present their views and facts as to what remedies they would advise and are capable of installing and maintaining; hearings to include any expert testimony submitted.

3. The collection of all available knowledge and data bearing upon the most approved methods of water purification and sewage treatment.

4. Formulation of advisable requirements for each locality according to local conditions and necessities as shown to exist as the result of the investigation by the commission and the report of its sanitary experts on the pollution of the boundary waters between Canada and the United States.

In proceeding with the investigation of this second branch of the reference it seems necessary as a first step to obtain from the most eminent sanitary engineers an expression of their opinion in answer to certain questions. These questions should be framed with the purpose of bringing out information which would enable the commission to formulate a general policy as to remedies based on sound sanitary engineering and economic principles. The questions to be submitted to eminent sanitary engineers should include the following:

GENERAL QUESTIONS.

1. Considering drainage from rural communities, agricultural lands, grazing lands, and unsewered towns, especially following rains and thaws, street washings from cities and sewage through storm-water overflows, is it possible to maintain waterways draining a populous area in a condition of such purity that they may safely be used as a source of water supply without purification?

2. Is the present degree of pollution of the Great Lakes or their connecting rivers prejudicial to the public health of either country?

3. Do you consider that unrestricted discharge of crude sewage into the Great Lakes or their connecting rivers should be permitted to continue?

4. On general principles, do you consider it safe to discharge crude sewage into waters used as a source of water supply for a municipal water purification plant?

5. In waterways where some pollution is inevitable and where volume is such that no general nuisance can result, do you consider that proper sewage disposal by dilution[1] represents a natural resource and that the utilization of this

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[1] "Proper sewage disposal by dilution" is here meant to include proper sewage outfalls, reaching the main current of a stream or discharging at a sufficient distance from shore and in water of a sufficient depth, in order to properly utilize the volume of water available for dilution.

resource is justifiable for economic reasons, provided that an unreasonable burden or responsibility is not placed upon any purification plant and that no other menace to the public health is occasioned thereby?

6. What do you consider to be an unreasonable burden[1] to place upon the bacterial purifying capacity of a modern efficient water-purification plant?

7. What do you consider to be an unreasonable responsibility to place upon a modern efficient water-purification plant?

8. Would you consider it proper and advisable to permit the discharge of sewage or sewage effluents under proper restrictive control up to a point where the degree of pollution did not impose an unreasonable burden or responsibility upon purification plants of public water supplies?

9. If the discharge of urban sewage was sufficient to render the raw water at the intake in question of such a character as to impose an unreasonable burden or responsibility upon the water-purification plant would you consider that sewage treatment had been carried far enough when the degree of pollution at the intake was reduced below that which constitutes an unreasonable burden or responsibility upon the water-purification plant?

10. Taking it for granted that it is impossible to control surface drainage from the countryside due to rain washings, etc., is it you opinion that modern efficient water-purification plants could adequately cope with this form of pollution?

11. Provided the discharge of urban sewage into any part of the Great Lakes or their connecting rivers is such that an unreasonable burden or responsibility is placed upon a water-purification plant, what methods of sewage treatment would you recommend to reduce the pollution to a point where no unreasonable burden or responsibility is placed upon such water-purification plant?

12. Even if water-purification plants properly constructed and efficiently operated existed in all municipalities, do you consider that indiscriminate discharge of sewage by vessels should be permitted?

When the answers to the questions submitted to the sanitary engineers are received they should be carefully reviewed by competent experts and provisions upon which there is practically unanimous agreement, enunciated as a general policy.

HEARINGS.

The questions and answers with the complete report of field work should be sent to all municipalities shown by the report of the sanitary experts to be responsible for the existence of avoidable pollution in these boundary waters in contravention of the treaty. These municipalities should be notified that the commission is now considering the second branch of the reference relating to remedies for pollution of these waters in contravention of the treaty, and that hearings will be held at stated times in certain cities for the purposes above indicated.

FORMULATION OF SPECIAL STANDARDS.

Local conditions and necessities will determine the measures necessary in each locality. No fixed rule or ser of standards could be applied to all the connecting rivers which would be sufficient in some cases without being in excess of the necessities in others. Obviously the formulation of standards of purity involves the specification of the degree of sewage treatment necessary to bring the raw water within these standards. So that a board in order to formulate standards would of necessity fix the permissible limits of pollution and define the measures of sewage treatment necessary to accomplish the desired result.

To properly gauge the sanitary necessities which will prevent pollution from one side being detrimental to the public health on the other, and to guard against the exaction of any unreasonable requirements in excess of these necessities, it is essential that the experts employed to formulate special standards be carefully selected. The following personnel of a working board to formulate standards on each waterway is suggested:

1. Two sanitarians (public health experts) of good standing and well versed in things relating to sewage and water supplies, including the transmission and epidemiology of water-borne diseases.

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[1] It is conceded that as a business proposition it is cheaper to purify water than sewage, but, nevertheless, it is believed by many that a decent raw water should be furnished to purification plants and that many plants are now struggling with a raw water which imposes an unreasonable responsibility and burden upon their capacity for purification.

2. Two sanitary engineers with special knowledge of sewerage systems and processes of sewage treatment.

The work outlined in the above plan may be considered as immediately devolving upon the commission; but under the terms of the second half of the reference (reference 2) there is apparently a more remote work, for about the middle of the second reference will be found these words, "and by what means or arrangement can the proper construction or operation of remedial or preventive works, or a system or method of rendering these waters sanitary and suitable for domestic and other uses, be best secured and maintained in order to insure," etc.

This would seem to imply that the commission was expected to either suggest or provide some kind of permanent machinery to control and supervise all remedial or preventive measures in the future. It is more than likely that the board for the formulation of special standards would be the most suitable "permanent machinery" for controlling and supervising all remedial and preventive measures in the future.

Now, gentlemen, that is the plan of procedure that the commission has adopted for the purpose of conducting the investigation of the second branch of this reference, namely, the remedies for the pollution which has been found to exist. At the beginning of the investigation of the first question the commission appointed a committee, consisting of Mr. Powell and Mr. Gardner, to take charge of the investigation of that question. Mr. Powell has the interrogatories which have been submitted to you for your study and consideration, and he will now proceed with the general examination.

STATEMENT OF MR. GEORGE W. FULLER, OF NEW YORK CITY.

Mr. Powell. You have had a good deal of experience in these matters?

Mr. Fuller. Yes, sir; I have had considerable experience.

Mr. Powell. Will you please give us a pretty full idea of your experience in these matters so that the public in Canada, at least, who may not know you so well as you are known in the United States, will have some idea of your position?

Mr. Fuller. I have made a specialty of matters of water supply and sewage disposal for some 25 years or more. I was a student at the institute of technology in Boston in 1888 at the time that the Massachusetts State Board of Health was reorganized on its present lines and when there was an effort made to get means of procedure to take better care of the public health. I am speaking of that date to accentuate the thought that it was shortly following the recognition of the germ theory of disease. I took the course in chemistry at the institute of technology and graduated from that department, taking many of the subjects which were later called a course by itself, that is, the course of sanitary engineering. I studied bacteriology at the University of Berlin and was for some months in the office of the engineer of the Berlin waterworks.

I then spent about nine years in this country making a special study of the best ways and means of purifying water and sewage. About five years of that time were spent at Lawrence, Mass., where the State board of health conducted an experiment station for the purpose of ascertaining the best way of purifying water and sewage under Massachusetts conditions. Then I was for about four years in Louisville, Ky., and in Cincinnati, Ohio, studying the best means of purifying the muddy and sewage-polluted water of the Ohio

River. I suppose there must have been $250,000 spent under my charge during those nine years in ascertaining from the engineering, chemical, and biological viewpoints what was the most practicable and reliable means of handling these problems of purifying water and sewage.

I have been in private practice since 1899 in New York City, and have had a good deal to do with many of the larger problems of municipal waterworks and sewerage. I have been consulting engineer of the water department here in New York City and have been connected with plans for filtration of the present or Croton water supply. I have also been one of the two sanitary advisors to the board of water supply that has in charge the construction of the waterworks that will bring Catskill water to New York City, having had particularly to do with the question of sanitation as related to the treatment of the bottom and sides of these reservoirs, the aeration of the water and the site and the best way of leading water to localities where filters later may be installed. I have had much to do with sewerage matters here in New York City. I was one of the experts called by the metropolitan sewerage commission to advise as to certain aspects of the treatment of the sewage of the city of New York.

I have been connected with probably 120 or 130 different water-supply projects in this country, including, perhaps, half or more of the larger cities of 100,000 population or over. I was connected with the water supply of Washington City. I was a member of the engineering committee, appointed by the United States Senate committee that had charge of the District of Columbia affairs, in 1901, to advise as to the method of filtration of the Potomac River water for Washington City. I was for about nine years a member of the board of advisory engineers at New Orleans that had much to do with the local drainage works, and also the water and sewerage works, including design, the supervision of construction and the operation of the system of works during its early history. I have been connected with the water-supply projects of Memphis, St. Louis, Indianapolis, Columbus, Louisville, Cincinnati, Minneapolis, Grand Rapids, Montreal, and, as I have already stated, there are perhaps 130 in all. I have also had a good deal to do with sewerage matters, and have served perhaps 100 or more cities in that line.

That means from an engineering standpoint that I had to do with the designing of sewers and the supervision of their construction, and also the means of disposing of the sewage, the design of sewage-disposal works and the supervision of construction of such works and the supervision of their operation.

Mr. Powell. Mr. Fuller, I think perhaps the best method of procedure would be for you to take your copy of the questions in order that they may be taken up seriatim. First, with respect to the general plan of the investigation, is there anything that you could suggest by which we could make it more complete and effective?

Mr. Fuller. No; not offhand. It appears to me to be a very comprehensive program.

Mr. Powell. It is sufficiently comprehensive?

Mr. Fuller. I should think so; yes, sir.

Mr. Powell. The first question is as follows:

> Considering drainage from rural communities, agricultural lands, grazing lands, and unsewered towns, especially following rains and thaws, street washings from cities, and sewage through storm water overflows, is it possible to maintain waterways draining a populous area in a condition of such purity that they may safely be used as a source of water supply without purification?

Will you kindly give us your views with respect to that?

Mr. Fuller. I have a very short answer to that question, and that is, "no." I am not quite clear as to whether or not you gentlemen wish me to comment on these questions. I would prefer to make specific answers.

Mr. Powell. By all means paraphrase it to any extent that you desire.

Mr. Fuller. I have but little to add to that answer of "no," because I am thoroughly convinced from my observation of water supplies, taken from a great many different sections of the country, that we must, as a general proposition, purify these surface waters. The reason for that is that there is no way by which you can keep the germs of diseases coming from intestinal discharges from reaching the mouths of water consumers of surface supplies unless you do resort to water purification. That is a plain statement of what my experience, covering many years, has led me to in point of general conclusion. There are, of course, some exceptions, but I am speaking of the general proposition. If you get to dealing with exceptions to general propositions, it will make the trend of thought less clear.

Mr. Powell. Just supplementing what you have said, I will take a couple of specific instances. There are streams along the international boundary line, such as the St. John River, where there is a rich and thickly populated rural community for, say, about 50 or 60 miles before that river reaches the border line. You would consider the water, then, of the St. John River, especially at its low stages, as being unfit as a source of water supply?

Mr. Fuller. As a general proposition, that is true. I have a little hesitancy in being too responsive to certain specific illustrations.

Mr. Powell. Not knowing all the conditions?

Mr. Fuller. Not knowing all the conditions, I do not desire to evade anything, but as a general proposition I should say that that is true in the instance you mention of the St. John River.

Mr. Powell. The same condition of affairs obtains in respect to the Rainy River, where there is quite a large rural or riparian population. You would expect at least to find the water unsafe there?

Mr. Fuller. Yes; I believe that a sound, safe, adviser to any community having to draw its water supply from that river would say that that water supply should be well purified.

Mr. Powell. I suppose it would be out of the question to call upon the different riparian proprietors or dwellers to purify the water from their lands? That is entirely unthinkable?

Mr. Fuller. Yes; that is not practicable.

Mr. Powell. In that case the only thing to be done would be to have the cities purify the water before it is used?

Mr. Fuller. Yes.

Mr. Powell. Would that be an expensive proposition, Mr. Fuller?

Mr. Fuller. No; as a general proposition, I should say it would not. I will illustrate it in this way: Taking the capital charges and the operating expenses as found here in New York City, the cost of filtration would amount to something like 30 cents per capita per annum.

Mr. POWELL. But the smaller the community the larger, relatively, would be the charge?

Mr. FULLER. That is true so far as the operation and maintenance are concerned. The investment per capita ought not to be materially different.

Mr. POWELL. In those cases would you generally recommend filtration or chemical purification by chlorination?

Mr. FULLER. I am a believer in filtration first and foremost. I believe that the chlorination method of eliminating or destroying disease germs has a great deal to commend it, and in many instances can be used advantageously as an adjunct to filtration.

Mr. POWELL. Of course you understand that I am directing your attention now to the water that is contaminated by the flow from the upland in rural districts.

Mr. FULLER. Yes, sir. I know there are instances where unfiltered water supplies are treated with chemicals, and water supplies of a good fair quality are obtained. Such a case is found in the Croton supply here in New York City. In my judgment it is not so good as it should be, and I believe that filtration should be considered a feature of all public water supplies along boundary waters.

Mr. POWELL. As this is one of the least important questions contained in this list, I think we can pass on to the second question, unless some of the other gentlemen have some questions to ask. The second question reads:

> Is the present degree of pollution of the Great Lakes or their connecting rivers prejudicial to the public health of either country?

That matter, I think, is pretty well decided by the data which the experts have collected during the last few months. Have you had a copy of the data?

Mr. FULLER. I have seen something of it. I am not very well informed as to all the details, but I know something of it. I know there are signs of very marked pollution in places.

Mr. POWELL. What would you care to say in respect to that?

Mr. FULLER. My answer after thinking that matter over is, "no"; not as a general proposition; but in speaking of that view I want to make it very plain that I am considering that the water supply should be obtained only in connection with a modern, first-class filtration plant, and I am looking at the boundary waters in the light of whether or not they are a reasonable source of raw water supply, which supply would be thoroughly and properly treated before it went to the householders.

Mr. POWELL. So that when you answer "no" to this question, it is on the condition that proper means of purification will be adopted, such as filtration or chlorination?

Mr. FULLER. Yes, sir; that is true.

Mr. POWELL. The Great Lakes in their central zones appear to be in virgin purity, or the next thing to it. If the water supply were drawn from there you would emphatically say "no." In cases of the water supply being drawn from the purer zones of these likes there would be no necessity of purification by filtration or by chlorination, I suppose?

Mr. Fuller. No; not in following out reasonably the program as we see the desires of our American and Canadian cities to keep their investment down. But I would say that that forms an exception to the rule, and that my viewpoint is very specifically lined up in my own mind to maintaining those conditions as exceptions and to holding the whole broad question on the line of the filtration of water supply.

Mr. Casgrain. I do not quite understand you, Mr. Fuller. The question here is: "Is the present degree of pollution of the Great Lakes or their connecting rivers prejudicial to the public health of either country?"

Mr. Fuller. My answer is "no," provided the water supplies will be always filtered before they are distributed to the householders in the different cities.

Mr. Casgrain. Then your answer would be this: That if they take the water, for instance, for drinking purposes from the Detroit River or the Niagara River, that it would be prejudicial to the public health?

Mr. Fuller. Yes; if that water were delivered to the consumers in its raw state, but taking things by and large I am looking at that water in the light of whether it is a suitable source of raw-water supply.

Mr. Powell. That is, you say that notwithstanding the contamination, it can be purified so that it would be suitable for domestic and other purposes?

Mr. Fuller. Yes, sir.

Mr. Powell. Would that be an expensive operation, Mr. Fuller? I do not wish you to go into details.

Mr. Fuller. No; not particularly so. The investment, interest charges, and operating expenses amount, as I have said, to something like 30 and 40 cents per capita per annum; much less than a great many people spend for bottled water.

Mr. Powell. The next question is:

> Do you consider that unrestricted discharge of crude sewage into the Great Lakes or their connecting rivers should be permitted to continue?

What have you to say as to that, Mr. Fuller?

Mr. Fuller. No. I think that the unrestricted discharge of crude sewage into the Great Lakes or the connecting rivers should be brought to an end, and that a reasonable and progressive control should be had over the discharge of the sewage. In making that answer I will say further that I believe that reasonable account should be taken of the ability of the water to absorb sewage by dilution, but, even so, I believe that the sewage should be subjected to some treatment, and that the unrestricted discharge of sewage should come to an end.

Mr. Powell. The question of what you might call restrictions would be a question to which different answers would be given according to the conditions and circumstances of the situation?

Mr. Fuller. That is so.

Mr. Powell. The more specific cases come up, so I think, gentlemen, unless you have some questions to ask Mr. Fuller, we can pass that matter. Take question 4:

> On general principles, do you consider it safe to discharge crude sewage into waters used as a source of water supply for a municipal water-purification plant?

That is a pretty broad question. What do you say to that, Mr. Fuller?

Mr. FULLER. I will answer that by saying "yes," provided the discharge of sewage is kept within reasonable limits.

Mr. POWELL. In order to shorten the examination, gentlemen, those of you who are waiting might follow Mr. Fuller closely, because you may wish to simply assent to his position with regard to these questions or you may wish to supplement his statements with some particular remarks of your own; so we can save time if you have the giving of your own testimony in view.

Mr. Fuller, I think you can submit a little further explanation of your answer to question 4. As I infer from what you said, you contemplate having two operations on parallel lines, so to speak; that is purification of sewage and purification of the water at the intake for domestic purposes. Am I correct in that view?

Mr. FULLER. Yes, sir.

Mr. POWELL. I also understand that the adjustment, so to speak, of these two factors is a matter that must be governed in many cases by circumstances.

Mr. FULLER. And local conditions affecting sanitation and municipal management.

Mr. POWELL. I do not wish to pin you down to an exact opinion with respect to the conditions at Buffalo, but take the case of that city which pours its sewage unrestrictedly into the Niagara River. What would you say about that; that that should not be tolerated?

Mr. FULLER. I believe that there ought to be an improvement over the conditions as to the discharge of sewage into the Niagara River. Whether there ought to be a very modest amount of purification of that sewage, whether it should be a matter of screening or putting it through large tanks to get out the solid fecal matter, or whether it should be subjected to sterilization or treatment with some of the oxidizing chemicals to destroy the disease germs or not, is something that I should hesitate to speak about in an offhand manner. It is too big a problem for a man to speak about offhand. I believe that the water supplies should be filtered as a general proposition. I am very strong in that view. I believe that as an added precaution in the direction of taking care of the public health it is wise to begin in a systematic way to install sewage-treatment works. There may be some places where it would not be wise to be too insistent upon having those works put in within three or five years. But it takes a long time to get a project of that sort on its feet. If it is wise ultimately to have sewage treated before it goes into waterways, that position should be declared, in my opinion, at a fairly early date so that all collecting sewers and arrangements of that sort can be adjusted to the end of having the sewage treated in a way that will lead to the best results.

Mr. POWELL. Take a large city on the banks of a stream which is used as a source of water supply. Generally speaking, what degree of purification of the sewage would you think should be insisted on as a minimum?

Mr. FULLER. I should say screening.

Mr. POWELL. That is to take out the coarse matter?

Mr. Fuller. The visible matter, refuse from kitchen wastes; that is, potato parings, etc., and toilet paper and things of that sort, eliminating the visible and obviously conspicuous solid matter.

Mr. Powell. Could that be done by screening or sedimentation?

Mr. Fuller. Screening is probably the cheapest way in which that could be done. That is the treatment that has been recommended, for instance, here in New York along our North River frontage.

Mr. Powell. Would you go further and say that ordinarily nothing should be done in the way of purification of the sewage, or would that be a question of condition?

Mr. Fuller. That is really a question of condition. There are many places where screened sewage might not find enough water for dilution, and where there should be a stranding of matters that would pass through the screen. After that you come to the second step of your treatment procedure, and that is sedimentation. There is one other feature that is related not so much to the ordinary nuisance phase as it is to the phase that we were speaking of a few moments ago, and that is protection of the public health in its relation to drinking water. I am speaking now of the sterilization of the sewage. Here in New York City, for instance, the water is salt and is used simply for high-pressure fire protection. There are no waters in these rivers used for drinking purposes, but there are cases where a water supply, even when subjected to filtration and even when further subjected to sterilization, ought to have the benefit of a reduced load, which could be affected by the sterilization of the sewage of a neighboring town.

Mr. Powell. Then, I suppose the question is really one of ratio between the quantity of raw sewage that is dumped into the river and the flow of the river itself, whether the situation is relieved by dilution or not.

Mr. Fuller. Yes; that is so. There are these three phases that I have spoken of: the screening of sewage, the use of sedimentation to take out the finer matters, and the question of sterilization to destroy objectionable disease germs. And, then, there is the fourth aspect, which has been a factor in a good many of our Eastern States, and that is to filter and take out much of the soluble and nonsettling organic matter.

Mr. Powell. Should an upper riparian city be compelled to purify its sewage before it is dumped into the water, so that the lower riparian cities shall not have an undue burden thrown upon them for the purification of their water for domestic purposes?

Mr. Fuller. As a rule the upper city does not treat its sewage before it is discharged into a stream.

Mr. Powell. They are allowed to throw their sewage almost unrestrictedly into the stream?

Mr. Fuller. There are many of our Eastern States now where that is not in compliance with the spirit or even the letter of the law, but within the range of my observation cities very seldom spend money on sewage disposal unless they are forced into it by lawsuits or by having a set of conditions that conspicuously result in a nuisance.

Mr. Magrath. What about the question of cost?

Mr. Fuller. That varies tremendously. The screening operation is not very expensive. The sedimentation becomes more so, and it becomes progressively increasing in the amount of money demanded with the degree of treatment that is effected.

Mr. POWELL. Now, as between the purification of water for domestic purposes and the purification of sewage, what is the situation looking at it from the standpoint of economy? Which should receive the greater attention?

Mr. FULLER. I am strongly for the filtration of water supplies in the interest of the public health, and I believe that that is where the public health is best protected. There are some engineers who even go to the point of saying that double filtration is advisable—that is, putting the water twice through filter plants—and having, if you will, not only all the automatic devices for aiding the reliable performance of these filters, but also high-grade technical supervision, which means a competent laboratory man on the job, so to speak, every hour out of the 24. Now, I, perhaps, am not so much an extremist as some, but I am very sincerely of the opinion that there should be filtration of practically all water supplies, and as a working program I do not believe I could suggest, so far as my trend of thought goes, to you gentlemen the recommendation of any other course of procedure.

Mr. POWELL. With regard to the methods of filtration, what is your experience as to the rapid or American style and the slow or the English style of filtration?

Mr. FULLER. They are entitled to equal standing, hygienically.

Mr. POWELL. How do they stand with respect to economy?

Mr. FULLER. That varies somewhat with local conditions, but there is not any very great difference. As a rule the mechanical filters, or the rapid filters, so called, are somewhat cheaper.

Mr. POWELL. As respects the initial installation and the cost of management?

Mr. FULLER. Both.

Mr. POWELL. Keeping the expert man that you have spoken about on deck would be necessarily more expensive than for the slow English method?

Mr. FULLER. Those filters, however, do get seriously into trouble at times; and I believe that there should be just as efficient management of the English type of filter as the mechanical type.

Mr. POWELL. As a matter of practice, which system of filtration is most in vogue to-day?

Mr. FULLER. The mechanical filters.

Mr. POWELL. The English system has been going down and the American system coming up in popularity, whether in favor or not?

Mr. FULLER. That is true in the States, and it is explained in part by the fact that so many of our southern and western waters are muddy to a point where we must use chemicals to get them in shape for filtration. When it becomes necessary to use chemicals, such as for the taking out of vegetable stains as in the water supply of this city, for instance, I believe the best thing is to put in a mechanical filter. I have been connected with the Croton project in this city and we recommended the older type of sand filters in 1907. That plant was not built because the financial difficulties of that autumn made the situation such with regard to marketing bonds that the project went to sleep. The matter was taken up again and mechanical filters were found to be materially cheaper. As I recall it, the cost was something like seven and a half million dollars for a mechanical filter plant and about ten and a half million dollars for a sand filter plant. I am speaking now of the Croton water supply for the old city of New York; that is, the borough of Manhattan.

Mr. CASGRAIN. Will you kindly give along general lines the difference between the two types of filters?

Mr. FULLER. The older sand filter with its English origin is a method which involves the passage of water through sand at a rate of about 4 inches drop in the water column per hour. In passing through the sand it has removed from it the bacteria and some of the suspended matter as well as some of the vegetable stain. That process is one which has served very excellently in western Europe. It has worked well in some places along our Atlantic seaboard. It is a method which has failed and has been very unsatisfactory in most of our Southern and Central States wherever it has been tried. The reason of that is that the surface of those sand layers clogs up so quickly and regularly. For instance, at Rock Island, Ill., the sand filter plant that was installed there was so very unsatisfactory that it was quickly superseded by a modern mechanical filter plant. This mechanical type of filter had a very modest origin. It was first used down in the Maine woods in the paper mills for taking out sawdust from the river waters. The water is passed through about 40 times as fast as through the other type. These sand beds are put in small tanks and they are cleaned not by scraping off a surface deposit, but by having water forced up from below, and the whole sand bed is agitated in that way to a point where it is substantially clean.

Mr. POWELL. That is, you let it run for a time and then reverse the current and drive the stuff to a point where it passes off?

Mr. FULLER. Yes; into a drain.

Mr. POWELL. That consumes a large portion of water, does it not?

Mr. FULLER. It runs from 2 to 3 per cent usually. I would state that these mechanical filters are operated through the aid of a little dose of alum in the water. This artificial coagulation process which facilities the removal of impurities from the water resembles in effect the little sticky film of organic matter which forms itself around the grains of sand in the older or English types of filter. That process of artificial coagulation, used with mechanical filters, masses together the particles in suspension a good deal like the way the white of an egg will clarify turbid coffee.

Dr. STARKEY. Mr. Chairman, may I ask Mr. Fuller to explain a little more in detail his answer to question No. 4? In answering that question, Mr. Fuller, do you consider it safe to discharge crude sewage into waters that are used as a source of municipal supply? You said that you would allow the discharge of water within certain limits. Can you define a little more clearly what you mean by that?

Mr. FULLER. I will try to get to that in connection with some of these other questions, if that is a fair response now.

Mr. POWELL. We will allow that matter to remain in abeyance. Take question No. 5:

> In waterways where some pollution is inevitable and where volume is such that no general nuisance can result, do you consider that proper sewage disposal by dilution represents a natural resource and that the utilization of this

> resource is justifiable for economic reasons, provided that an unreasonable burden or responsibility is not placed upon any purification plant and that no other menace to the public health is occasioned thereby?

There is considerably dubity about this unreasonable burden in my mind, but you can wrestle with the question to the best of your ability.

Mr. FULLER. My answer is that I do consider that proper sewage disposal by dilution represents a natural resource and that the utilization of that resource is justifiable. The whole keynote of the proposition is a matter of keeping that burden, or responsibility, where it belongs.

Mr. POWELL. That leads us to a definition of what unreasonable responsibility is. There is a specific question there, is there not? I think, Mr. Fuller, that question 5 has been gone into quite fully. Now we will take up question 6. Here is something that kings and prophets waited for but never found:

> What do you consider to be an unreasonable burden to place upon the bacterial-purifying capacity of a modern efficient water-purification plant?

Mr. FULLER. I have given some thought to framing an answer which would be lined up to the methods of the laboratory man, the bacteriologist. And I know personally quite a number of filter plants where the volume of sewage in the raw water is fully as much as it ought to be, and yet those filters seem to give a thoroughly reliable public water supply. The test for B. coli is made quite a feature of the work of this commission, and if the occurrence of B. coli in the raw water is found in 1 c. c. samples to be 100 per cent of the time, you get to a point where the water becomes bad from the filter superintendent's viewpoint. I want to make it plain in this answer that you can get a raw water much worse than that and still not get into trouble. Probably difficulty would not arise with a good filter plant well operated, when the raw water showed in one-tenth c. c. sample positive B. coli results 50 per cent of the time. Where it is advisable to begin to apply chemicals to sterilize a sewage entering the stream forming that raw water supply is a thing that brings up questions of policy that it is hard for me to speak of in a very concise way. But my general answer is that we can safely take a raw water which, as a yearly average, would have in 100 cubic centimeter samples, say, roughtly, 500 B. coli, or, in other words, the rough limit I place at water showing in one-tenth c. c. samples positive B. coli results in 50 per cent of the tests. That is as definite and responsive an answer as I can make.

Mr. POWELL. You think that would be the limit of burden to throw on a purifying plant?

Mr. FULLER. I think the plant could handle a water much worse than that, but I believe that the limit should be kept conservatively low. I think it is in that general neighborhood where I would want to draw the line. There may be evidence that I do not know about that would lead others to consider the matter differently, but from what I have been able to gather together as to records of filter plants with which I am familiar; that is, the approximate standard of analysis to show the upper limit in amount of pollution in the unpurified water.

Mr. POWELL. Taking an upper riparian city whose sewage is thrown into the river which is the source of water supply for lower riparian communities, you would say that the water should pass to those lower riparian communities with not exceeding this degree of pollution which you have referred to?

Mr. Fuller. I think it would be desirable to make the treatment of the sewage come in as an actual working part of your program if need be to get the raw water supply of the lower community to this basis.

Mr. Powell. You spoke about an unreasonable burden. What is the effect of throwing contaminated or polluted water upon a plant? Would not a certain amount of bacteria pass through?

Mr. Fuller. Yes; the filters are not germ proof. When used in connection with sterilization, such as hypochlorite of lime, they are reliable as germ removers to a higher limit; but even at best they are not absolutely fool proof or germ proof, and it is to guard against the effect of occasional accidents that you would desire to keep some limit in pollution of the raw water reasonably well in hand. I am myself a pretty strong believer in having a good, efficient management of water-filter plants and in earlier years thought that money might be better spent to get a water supply twice filtered, rather than to put a certain portion of the public funds into a water-filter plant and a certain portion into a sewage-treatment device. But since these relatively economical means of sterilizing sewage have come to the front, and screens and sedimentation basins are found to be easier to build and cheaper to operate than was formerly the case, I have modified my views somewhat, although I am still a firm believer in water filtration and in good management of such a plant.

Mr. Powell. As I understand it, no promise of filtration can guarantee absolute immunity from bacteria?

Mr. Fuller. It is hardly possible to get an absolutely sterile water every minute of every day in the year from any filter plant, but it can be approached quite nearly now that we have these sterilization arrangements to help out the filters.

Mr. Powell. What is the effect on health of the use of these chemicals? Is it an effect that is worthy of taking notice of at all?

Mr. Fuller. No; it has no effect that can be detected.

Mr. Powell. Nothing deleterious?

Mr. Fuller. No; there has been a good deal of sentimental objection to the use of sulphate of alumina, but I do not believe it has any basis in fact at all.

Mr. Powell. They are both purifying agents, sulphate of alumina and hypochlorite, but they are for different purposes. One is for coagulation and the other is for the killing of germs?

Mr. Fuller. Yes.

Mr. Powell. Speaking of both, has either one any deleterious effect upon health?

Mr. Fuller. No.

Mr. Powell. But they have an effect on making the water somewhat disagreeable if used to excess?

Mr. Fuller. Yes; that is so in regard to the hypochlorite of lime or liquid chlorine. In some of our waters along our seaboard States there is now and then a possibility of quantities reaching the water in excess of that which could be decomposed or absorbed by the organic matter in the water. The excess gives a taste which is noticeably objectionable. Sulphate of alumina is decomposed by the lime and magnesia in the water. It so happens that the amount of lime and magnesia in the water of the Great Lakes system is such that it would decompose, I should say, 10 times as much sulphate of alumina as there is ever any need of using, so that the risk of having any undecomposed sulphate of alumina reaching the water consumers would be very remote.

Mr. Powell. Generally speaking, which is the more economical, to purify your water by chlorination at the intake or to purify the sewage discharge?

Mr. Fuller. It is cheaper to purify the water at the intake.

Mr. Powell. And that effect would be emphasized according to the amount of dilution there was to the waters of the stream to which the sewage may enter?

Mr. Fuller. I think that is true as a general proposition, but there may be some exceptions where you would perhaps have to apply filtration, if I gather your point correctly. But to get back to the thought that I tried to bring out before—I believe that when the load or unreasonable burden is over 500 B. coli per 100 c. c. in the raw water, I would be disposed to say that I would want to have some treatment of the sewage, or if such treatment had been in effect for some time I should be disposed to consider means of purifying the sewage to an extent greater than had been the practice up to that time?

Mr. Powell. Take Question No. 7:

> What do you consider to be an unreasonable responsibility to place upon a modern efficient water-purification plant?

That is general. You say you are not limited to bacterial purification.

Mr. Fuller. I would be disposed to hold that to the bacteriologic side.

Dr. McLaughlin. I think it was intended to be on the bacteriologic side. The responsibility is the requirement of such a work to be done every day in the year. Now, plants can take care of a burden that may be an excessive burden, but to ask them to do that every day in the year constitutes an unreasonable responsibiliy. There is a slight difference between an unreasonable responsibility and an unreasonable burden. Filter plants are subject to ordinary human errors, so that the responsibility is enormous on a plant that is taking care of such a raw supply, and, as Mr. Fuller says, doing it every day in the year.

Mr. Powell. Or there may be the large margin of safety, to use the language of engineers?

Dr. McLaughlin. Yes.

Mr. Fuller. The men who have been down through our Southern States and have seen those muddy or swampy waters must all feel that the sewage pollution aspect is not so strong. It does not make the demands upon the operating men that the rapidly changing conditions of the muddy stream do. Something of that sort would apply here in New York with our croton water, where the water has a vegetable tinge. I believe in having filter plants well equipped with laboratories and workingmen, perhaps, to a little greater extent than

Dr. McLaughlin thinks I do, or what he would formulate as a general representative operating schedule from what he sees in visiting various cities along these international boundary waters. Even in towns of less than 20,000 population, certainly in towns of that size and greater, I think there has been no instance where I have not designed works that did not provide for laboratories, and I believe there should always be a man competent to make analyses on the ground. Of course, in these larger cities where we have had to provide water softening, not only is there a competent laboratory staff, but those laboratories are manned 24 hours in the day. There is a competent technical man put on the night shift.

Mr. Powell. That suggests another factor. With respect to the men who are running the plants, should they be skilled men, or could you pick up any man and charge him with such duties?

Mr. Fuller. Filter attendants are a sort of selected laborers that are usually picked up from the contractors' forces around the jobs during construction. They are usually paid from $60 to $80 a month. The laboratory men, of course, get more money than that. But I have been always desirous, if I could do so, and have as a rule been able to bring about this style of an organization; that is, put a man in charge of the plant and have him a laboratory man. It is not always the case that it works out in such a way that you can get hold of a man who will have the laboratory or scientific knowledge and at the same time have the gumption to get along with the laborers; but that is the thing we strive for in my office.

Mr. Glenn. Would you consider it right and proper for us to allow a town upstream to pour its sewage into that stream, thus affecting the towns lower down, and force the towns lower down to put in a filter plant, even though they could successfully do that; or ought we to require the town upstream to filter its water so as to make a less burden on the towns below? In other words, for example, should Buffalo be allowed to empty its sewage into the river so as to almost destroy the water at Tonawanda? In justice, ought we not to require these fellows to purify their water?

Mr. Fuller. From the standpoint of equity that might be so, but as a practical proposition Buffalo being so much larger than Tonawanda, the expense would be so great that they could better afford to sell the water from the Buffalo city mains to Tonawanda. If there is no nuisance in the Niagara River, and if the towns in the lower valley there can get water which would not overtax seriously the filter, I believe the treatment of the sewage should be comparatively small. It might be screening or some sterilization.

Mr. Casgrain. We are looking at it from the standpoint of the treaty, which refers to pollution that extends across the boundary, the pollution which is created in the United States and extends to Canada, or vice versa. We have nothing to do with the pollution which arises in Buffalo and affects the water that Tonawanda takes.

Mr. Powell. We will now take up question 8.

Would you consider it proper and advisable to permit the discharge of sewage or sewage effluents under proper restrictive control up to a point where the degree of pollution did not impose an unreasonable burden or responsibility upon purification plants of public-water supplies?

I suppose, Mr. Fuller, we could glean your answer from what you have already said?

Mr. Fuller. Yes.

Mr. Powell. But you would have the discharge purified to 500 B. coli per 100 c. c.?

Mr. Fuller. In that general neighborhood. I perhaps ought to suggest that these figures are not as precise as they may seem to a reader of these records, or as I may state them. I do not want to be thought to have more knowledge than I have. I do not think anyone can answer that question in very precise terms. I am just forming a general judgment based on my observation at many places.

Dr. McLaughlin. I quite agree with Mr. Fuller. I do not believe anybody can say exactly and in precise terms what constitutes an unreasonable burden on a filter plant: and I think, in view of that fact, that our margin of safety should be an ample one. It is conceded that bad river waters can be treated and made into safe water supplies, but many, I think, are accepting those conditions because they are inevitable. In the Lakes we have these great reservoirs of comparatively pure water, and I think we should keep them as they are at present. I believe that it would be better in speaking of the margin of safety to have a raw water of about 100 B. coli to 100 c. c., rather than 500; but I quite agree with Mr. Fuller that it is not possible to fix that point precisely. You might argue one figure just as well as the other. I rather lean to the lesser figure, in view of the fact that we have relatively pure water to begin with in these basins.

Mr. Powell. With due regard to the ample margin of safety, what purification would you say should be imposed upon the upper riparian community in respect to its sewage?

Mr. Fuller. If I gather correctly this question No. 8 in its significance, I will go back to my answers to some earlier questions, and say that I believe there should be set under way means to keep all this sewage treated to a minimum extent. But I can see, of course, the lack of logic if you allow the water supply end to control and if you do not overburden the raw-water supply of the lower city in that it might not be necessary always to have any sewage-treatment works in the upper city. I can see how a small town might discharge sewage into a river where there would be a city below drawing its water supply from that river, and where there would not be any overburdening or overloading of the water-filter plant of the lower city due to the crude sewage of the small town above. I am speaking of that apparent inconsistency in my answers to earlier questions as I believe there should be, as I said, restrictions upon the discharge of sewage in practically all cases. I am speaking of that in the line of its taking not months but years in getting these movements under way.

Mr. Powell. With proper regard to an ample margin of safety, what would you say would be the condition in which the water of the lower riparian community should reach the intake?

Mr. Fuller. That bacterial test of 500 B. coli per 100 c. c. of water.

Mr. Powell. Is that in your judgment, however, an ample margin of safety?

Mr. Fuller. I think it is, taking seriously as I do the necessity of building water-filter plants in a careful way and operating them in a careful way, and I believe in technical supervision of those filter plants, as I have repeatedly stated.

The CHAIRMAN. Gentlemen, we will now take a recess until 2 o'clock.

AFTER RECESS.

Pursuant to the taking of the recess, the commission met at 2 o'clock p. m.

The CHAIRMAN. Gentlemen, we will now proceed with the examination of Mr. Fuller.

Mr. POWELL. Mr. Fuller, we will next take up question No. 9, which is as follows:

> If the discharge of urban sewage was sufficient to render the raw water at the intake in question of such a character as to impose an unreasonable burden or responsibility upon the water purification plant, would you consider that sewage treatment had been carried far enough when the degree of pollution at the intake was reduced below that which constitutes an unreasonable burden or responsibility upon the water purification plant?

Mr. FULLER. I will answer that by saying yes. It becomes almost a matter of logic, as I look at it. If the last part of the question relates to correct premises, then the affirmative deduction almost follows as a necessary sequence.

Mr. POWELL. Are there any questions that any of you gentlemen wish to ask with regard to that matter?

Dr. STARKEY. I would like to ask Mr. Fuller whether or not he agrees with the fact that fresh sewage should be looked upon as more dangerous than remote sewage, that is, sewage that has been in the water for a long time?

Mr. FULLER. Other things being equal, that is so, because disease germs do not multiply in water but progressively and gradually die, so that the older and more remote the pollution is the less is the potential danger to health.

Dr. STARKEY. In view of that agreement and seeing that the commission is confronted with questions relating to fresh sewage in nearly every instance, would that tend to induce you to modify your standard which you have laid down, namely, 500 B. coli in 100 c. c. of the raw water?

Mr. FULLER. No. I have really taken that into account, having in mind where I lived for five years in the Merrimac Valley, that the Lawrence intake is only about 8 miles removed from the Lowell sewers. That is really fresh sewage. Another striking illustration that is similar in its scope and relationship is that of the Albany intake just below the sewers of Troy. I had in mind the recent pollution in answering that question.

Dr. McLAUGHLIN. Did you take into account also, Mr. Fuller, the use of hydroclorite as an adjunct in effecting the purification of surface water?

Mr. FULLER. I should to-day, but it is a fact that at Lawrence it has never been used.

Dr. McLAUGHLIN. The results at Lawrence show that the raw water without its use has been of such a character that they seem to be unable to cope with it successfully.

Mr. FULLER. I do not know the recent experiences at Lawrence very well, but, as a broad practical proposition, I know that they have not had much, if any, typhoid fever there.

Dr. McLaughlin. They have not had any epidemics, but we do not know just how much typhoid fever they may have had due to this. They have not been getting a satisfactory effluent. The point I was trying to make is this: I believe hypochlorite as an adjunct should be something that we should have up our sleeve as an additional factor of safety; that we should not require a filter plant to handle raw water that is worse than it can care for without hypochlorite; and that we ought to naturally have raw water of such a character that the plant can take care of it without hypochlorite. Such raw water I believe would have to be better than 500 B. coli per 100 c. c., although I admit that such water can be cared for by hypochlorite in the effluent.

Mr. Powell. Have you any observations to make in reply, Mr. Fuller?

Mr. Fuller. I do not know that that modifies my views at all. I think from my observation my stand is a reasonable one, leaving out the hypochlorite, but while we have that available, as we have at the present time, I believe it ought to be used. There is one thing I would like to speak of, and that is some of the capriciousness that may associate itself around these B. coli tests that are being put into this record as of almost controlling importance. In my day at Lawrence, where we used the determinative test—I am speaking of back in 1892—we found by actually plating out samples of water and using full determinative tests we had 50 or 60 B. coli per 1 c. c. I believe that this water standard that I have been speaking about carries only about one-tenth as much pollution as does that Merrimac River water. The city of Lawrence is very similar to Lowell in many ways. It is a mill town. Lowell had a ground-water supply introduced about the same time as the supply at Lawrence. Those two cities had a very low death rate for American cities, notwithstanding the fact that those operatives of those large mills are exposed to some extent to that raw water. Where there is raw water available you can not prevent the employees from drinking it at times.

Now, getting back to the question of B. coli, the experience at Cincinnati, I believe, is worth speaking about briefly. During the days when we ran a testing station there, 1898, the water was drawn from the old intake adjoining the Pennsylvania Railroad yard, and there were some 32 sewers that discharged water into the Ohio River above that intake. There was also drainage from the Little Miami Valley, a very populous area, entering the Ohio River above that intake. We found then by the methods of testing for B. coli in vogue that about 60 per cent of the 1 c. c. samples showed a positive result. They moved that intake 8 miles above the old intake and above the Little Maumee River, and they found in 1907, before they put the filter plant in operation, that there was a very marked improvement in the quality of water as judged by its effect upon the public health of that community. They found, according to the test for B. coli as now practiced, that from 85 to 90 per cent of the 1 c. c. samples showed a positive result, and notwithstanding the fact that the water comes from above all local sewage and the Little Miami River. This shows a capriciousness in these laboratory results that prompts me to speak very frankly of that angle as having a good deal of significance in my mind, and taking the whole question by and large I am a little bit afraid that if you are going to run on the B. coli standard alone there may be some likelihood of having the viewpoint somewhat misjudged by some. I believe further that the records ought to show that this B. coli test does not necessarily mean even bacteria from immediate intestinal content. That is, as I understand it, sour milk bacteria will respond to these tests, and I am a little bit uncertain as to whether there has not been too much seriousness placed upon B. coli data.

Mr. POWELL. What other tests do you think should be made in addition to the B. coli test?

Mr. FULLER. I do not know of anything that could be substituted to any better advantage. Of course, the ideal thing to do would be to make a test of the specific germs of disease, like the typhoid fever bacillus. That, I believe, can be tested for with some degree of success, provided there is enough infection in the water, but with the exception of one or two laboratories, I do not believe that that test is ever made. It is certainly far beyond the scope of my experience.

Dr. MCLAUGHLIN. Do you believe that the B. coli test is the best index available at present of sewage pollution?

Mr. FULLER. If there are no B. coli in the water, then I think you can say that that is the strongest proof that you can produce as to its good quality, either of original purity or of efficiency of purification.

Dr. MCLAUGHLIN. In dealing with these lake waters from one end of the chain to the other is it not rather significant that when we get the lake water remote from serious urban sewage we find almost a complete absence of B. coli?

Mr. FULLER. Yes. Your B. coli test, in other words, is a better criterion when you are judging the waters of the Great Lakes than when you are judging the streams inland or our own interboundary streams.

Mr. POWELL. There may be harmless bacteria in very large quantities, I suppose?

Mr. FULLER. Yes; we know that.

Mr. POWELL. The significance of the bacteriologic test is that it determines the conditions in which the deleterious bacteria, so to speak, may exist?

Mr. FULLER. Yes; may exist. That is, it is dealing with the potentiality of the situation.

Mr. POWELL. It determines only the potentiality of injury to humanity.

Mr. FULLER. That is true. I was speaking a few moments ago about a desire to go on record here as not leaving out something by way of explanation which possibly might frighten people who read a record like this, if this is ever to be printed. I have seen recently some rather striking illustrations of where people have gotten frightened by what they supposed to be the significance of B. coli.

Mr. POWELL. If there are no other questions, gentlemen, we will pass on to question No. 10:

> Taking it for granted that it is impossible to control surface drainage from the countryside due to rain washings, etc., is it your opinion that modern efficient water-purification plants could adequately cope with this form of pollution?

Mr. FULLER. The answer to that question is yes.

Mr. Powell. Where are you more likely to find this large percentage of harmless bacteria—in streams that flow by agricultural or rural lands?

Mr. Fuller. The B. coli?

Mr. Powell. Yes.

Mr. Fuller. I suppose the sewage-polluted water contains it in large quantities, but the harmless members of that group are found in the soil washings of agricultural lands. There are some grains which allow bacterial growths that respond to these presumptive coli tests in a positive way.

Mr. Powell. Now, take question No. 11:

> Provided the discharge of urban sewage into any part of the Great Lakes or their connecting rivers is such that an unreasonable burden or responsibility is placed upon a water purification plant, what methods of sewage treatment would you recommend to reduce the pollution to a point where no unreasonable burden or responsibility is placed upon such water-purification plant?

That is the crux of the whole business, although the answer is involved in what you have already stated. What method would you recommend to reduce the pollution?

Mr. Fuller. I believe that there should be the screening of the sewage and sedimentation to remove the solid matters, which will subside, and then, perhaps, the most important of all is the sterilization of the sewage.

Mr. Powell. Reduce it down to the standard that you have previously spoken of?

Mr. Fuller. Yes. So far as the filtration of the sewage is concerned I am not so sure that that is required in many of the instances that you may have before you. It may or may not be so.

Mr. Glenn. In ordinary cases would the screening do?

Mr. Fuller. In a good many cases, yes; provided there were no complications from the water supply standpoint, and, if so, I think sterilization should be used. I think sterilization is the most important thing of all as a general proposition. This question of organic matter which might be removed by filtration is one that I associate with the question of whether or not it overburdens the diluting capacity of the water. And I am not looking at it very seriously from the angle of influencing the filtration of the water or even influencing public health. The organic matter of sewage, the dead organic matter as distinguished from the living germs, has not any significance that I know of, except in a sentimental way. Of course, we do not want to take raw waters and even subject them to filtration and picture too vividly what the history may have been of that water. All waters have passed through the history of coming in contact with fecal matter. That is true even of streams in the virgin forests and of springs of unquestioned purity so far as disease germs are concerned.

This statement may be of some interest, and that is, in the early eighties, prior to the germ theory of disease, the United States Government had a national board of health. In those days chemistry was the yardstick for measuring the pollution of water supplies. I speak of chemistry now as against bacteriology. They found in some of those reports—I think it was for the year 1882—that if the content of polluted waters was measured in terms of nitrogen, carbon, and the other constituents of the ordinary organic content of water—if those specific amounts in the waters that they were working on should be representative of the same elements as found in strychnine, which is an active poison, a person would have to take all at one dose something like half a gallon of the water in order to get the amount of strychnine that was given for a single medicinal purpose. It makes rather a striking illustration of one aspect of this problem. I have been speaking here to-day having in mind especially the danger coming from living organic matter. The dead organic matter does not appeal to me as one of great significance. Sentimentally it is of importance, but when it comes to spending large sums of money I would hesitate considerably toward considering that a vital part of a program. I recognize that for some interior towns the filtration of sewage is important to reduce the organic matter, to prevent putrefaction.

Mr. POWELL. Is water a means of transportation of germs of other zymotic diseases as well as typhoid fever?

Mr. FULLER. Yes; dysentery and Asiatic cholera are conspicuously water borne. The changing from an impure to a pure water supply also affects the death rate of the town by means other than typhoid fever.

Mr. POWELL. We will now take the last question:

> Even if water-purification plants properly constructed and efficiently operated existed in all municipalities, do you consider that indiscriminate discharge of sewage by vessels should be permitted?

Municipalities, of course, means communities bordering on the waters.

Mr. FULLER. I am inclined to think that it would not make a great deal of difference so far as the municipalities are concerned if they had sufficient water-purification plants whether the discharge of sewage from the vessels is practiced or not. I believe that a great deal of care should be exercised in having vessels supplied with water in port of a quality that is above reproach, and that the indiscriminate taking of water by vessels is something that ought to be stopped. There is still another angle, and that is the question of whether the sewage of vessels does not make it rather dangerous, perhaps, around bathing beaches. I have heard that matter discussed rather seriously, but more particularly as regards city sewers themselves. It has also been discussed from the angle of what the sewage of the vessels might do in affecting public health at beaches, but that is a pretty small matter it seems to me on present evidence.

Mr. POWELL. What would you say with regard to the discharge of sewage from vessels at the intakes of these connecting rivers?

Mr. FULLER. I do not think it is a desirable thing to do; but if the water supply is well filtered, I do not believe that it should seriously overtax the capacity of the filters.

Mr. POWELL. Have you any information as to the question of sewage disposal from the vessels in the Great Lakes and their connecting rivers?

Mr. FULLER. I know it is quite a factor; yes, sir.

Mr. POWELL. It appears from the report of the sanitary experts that the steamboat population on the Great Lakes and their connecting rivers in 1912 was something over 15,000,000 souls. Would that indiscriminate disposal of the sewage of vessels carrying a population of that magnitude seriously affect the purity of the waters, in your judgment, especially in the connecting rivers?

Mr. FULLER. It might be a factor, but I never had considered it conspicuously so.

Mr. POWELL. Had you considered it from the standpoint of the aggregate of the steamboat population?

Mr. FULLER. Not by the aggregate. I have studied it pretty carefully in connection with conditions at Chicago, where there is no filtration plant and where three out of the four intake tunnels have their water sent to the consumers even without hypochlorite treatment.

Mr. POWELL. The steamboat population of Lake Michigan at Chicago is comparatively small to that which passes through these more restricted areas of water connecting the Great Lakes.

Mr. FULLER. Probably that is so, but I am speaking from the Chicago experience viewpoint.

Mr. POWELL. I understood you this morning, Mr. FULLER, that in purifying water and taking one community with another, it averaged about 30 cents per capita.

Mr. FULLER. Thirty cents to forty cents per capita per annum.

Mr. POWELL. Take water that is free from the solid particles. Of course there would be a variation according to the degree of water, but what does it take ordinarily to purify it by chlorination?

Mr. FULLER. It costs ordinarily from about 10 cents to 50 cents per million gallons, depending somewhat upon the volume of water treated and the amount of chemical added and the question of whether or not special labor is required for this purpose.

Mr. POWELL. Just a supplemental question to that of Mr. Tawney: There is on an average a vessel of 3,500 tons passing in the Detroit River every 13½ minutes. Do you not think that there would be a zone or a streak which would become contaminated and unfit for drinking purposes?

Mr. FULLER. Surely, if the water is taken raw from the immediate path or lane of travel, but the experience there at Chicago is rather striking in showing that it is not a tremendously big factor.

Mr. POWELL. The going traffic is on a certain line and the returning traffic is on another, especially with steamboats, and these two zones would be very apt to become considerably contaminated. That would be injurious, would it not, to the inhabitants of vessels or the crews of vessels which take their water raw from the Lakes?

Mr. FULLER. Yes: I do not believe that should be allowed if it could be reasonably prevented. I am speaking of raw water for drinking purposes.

The CHAIRMAN. Mr. Fuller, do you think from the standpoint of the health of communities whose intakes are in the connecting rivers—that is, rivers connecting the Great Lakes with the very large aggregate of steamboat population—that the interests of the public health require some international regulation for the disposal of vessel sewage on the vessels themselves?

Mr. FULLER. I can see how that would be very desirable, but if the water is filtered I do not think it is a tremendously big factor.

The CHAIRMAN. That is independent of the effect upon the health of the passengers on the boats themselves.

Mr. FULLER. I do not believe those passengers should be supplied with drinking water taken promiscuously out of port. I have not made a special study of it.

The CHAIRMAN. You are aware of the fact that there have been numerous and serious epidemics of typhoid fever on vessels due to the drinking water which the vessels themselves supply to their passengers, are you not?

Mr. FULLER. Yes.

Dr. McLAUGHLIN. Mr. Fuller, would you not say that it would be a very desirable thing if the additional burden on plants, if such plants existed, could be removed; that is, the burden that is added to those plants by passing steamers? It would be a desirable thing if such additional burden could be readily removed, would it not?

Mr. FULLER. Yes; desirable; but whether the game is worth the candle or not I would hesitate to say right now.

Dr. McLAUGHLIN. Is it not a fact that a large passenger steamer going into Chicago uses the waterworks intake as a steering point and comes rather close to it?

Mr. FULLER. Yes; that is true.

Dr. McLAUGHLIN. It is also a fact, is it not, that within half an hour of the entry into port nearly everybody uses the toilet on the boat?

Mr. FULLER. A great many of them do.

Dr. McLAUGHLIN. It is also true, is it not, that typhoid organisms in a typhoid carrier are very frequently in the urine as well as in the feces?

Mr. FULLER. That is so.

Dr. McLAUGHLIN. In view of those facts, then, it would be a desirable thing, if it is feasible, to cut off this added pollution?

Mr. FULLER. Yes; it certainly would be highly desirable if the water is taken raw.

Dr. McLAUGHLIN. Even if the water were filtered or treated, would it not be an additional safeguard if the raw water were protected to that extent?

Dr. STARKEY. Suppose laws were laid down providing that the steamboat people were not to take the water out of the Lakes which was known to be contaminated. Do you suppose, Mr. Fuller, that those laws would be respected?

Mr. FULLER. I do not know from personal knowledge. I imagine that there might be the taking of water from random places.

Dr. STARKEY. The discharge of sewage by boats could be eliminated to a very large extent, could it not?

Mr. FULLER. Yes; it could be eliminated to a very large extent.

The CHAIRMAN. I suppose you would have to penalize those who violated any international regulations?

Mr. FULLER. Yes.

The CHAIRMAN. It would depend upon the penalty and the enforcement of the law as to whether or not it could be done.

Mr. POWELL. Are there different schools of thought in respect to this matter of water purification and sewage purification?

Mr. FULLER. I presume there are.

Mr. POWELL. Are you all substantially agreed?

Mr. FULLER. That is rather a hard question to answer. I believe that the people who come most in contact with this line of work, and know how difficult it is to get funds, have rather a different viewpoint from those who look at it from what might be called a book angle—an academic angle.

Mr. **Powell.** Those academicians who look at it from the angle to which you have referred think all sewage should be sterilized before it is allowed to go into a stream at all?

Mr. **Fuller.** Yes; or even before it leaves the household.

Mr. **Powell.** Does that comprise a large division of scientific men?

Mr. **Fuller.** There are quite a number who belong to that school.

Mr. **Powell.** Who adhere to those views?

Mr. **Fuller.** Yes.

Mr. **Powell.** But the percentage of the general mass of people who are engaged in sanitary matters would be small who hold those views?

Mr. **Fuller.** I think that is true, so far as concerns the people who come actively in touch with the problems for the public health, and particularly from the financial or business side.

Mr. **Powell.** Then it all comes down to this, I suppose: That, like the railroad principle of having rates that the traffic will bear, you want as much purification as you can get, consistent with the ability of the people to bear the cost?

Mr. **Fuller.** Yes; I think that is a fair statement. I believe that it is possible to carry sewage disposal to a point where it does not give as good a return to the citizen as other means of spending money for the public good.

Mr. **Magrath.** In the relation that exists between America and Europe in the matter of the treatment of water and the treatment of sewage, where do we stand in comparison with them? I will go further: Are they further advanced than we are on this continent? To what extent are we overtaking them? I would like to have you on record with regard to that feature.

Mr. **Fuller.** As regards water-supply matters, I think that about 20 years ago the lesson which was learned from the cholera epidemic at Hamburg led the people of western Europe—that is, Great Britain, Germany, and France, etc.—either to get ground water supplies or, if they had to use surface waters, to filter them and purify them well, unless this was previously the vogue. In this country about 20 years ago is the date marking the close of a period of about 25 or 30 years during which there was no progress made at all in the field of water purification. Then work was done which resulted in the successful use of coagulates and allowed muddy waters and stained or colored waters to become purified. Mechanical filters came to the front. I suppose there has been much more actual progress made in this country in the last dozen or 15 years than there has been in western Europe; but we are still behind western Europe as regards quality of water supply, I should say, if we spoke of the percentage of population on the two sides of the Atlantic that had good and pure water.

As regards sewage purification, 20 years ago there was very little done in this country other than to protect the watersheds of the public water supplies of New York and Boston. There were several sewage-filtration plants put in to keep the pollution away from these two impounded water supplies of these two large eastern cities. There were a number of little straining devices on Long Island and at Atlantic City and Long Branch and generally along this string of pleasure resorts in this general locality. Getting outside of these two groups of American towns, I think it is safe to say that either litigation or threatened litigation explains the existence of almost every sewage-disposal plant that was in existence 20 years ago. Since then the State laws have become much more strict. There has been a good deal of litigation, and there has been a good deal of improvement, but it has not been a very striking record. I think it is fair to say that the last few years have seen two or three viewpoints developed here among the majority of men who knew about sewage disposal affairs on this side of the Atlantic. One is that there are too many of our streams that show stranded solids and visibly conspicuous matter of sewage origin on the stream beds, and there ought to be and must be a general movement to get cleaner rivers. The other is that disinfecting or sterilization will do a good deal toward improving the public health in its relation to polluted water supplies.

Getting back to Europe, there are two distinct viewpoints exploited there. In Germany clarification of sewage is what they are after. Clarification, fine screening, and sterilization has been used by the Berlin authorities; that is, whenever there are epidemics they make the reservation that these little settling basins shall be used for disinfection of sewage whenever they order it. Germany has been wrestling with trade wastes and has some rather difficult conditions to face. I think it is realized that England has allowed sewage disposal matters to drift along to a point where it is very hard for them to accomplish what they seek to-day. There are a great many manufacturing communities, such as in Lancaster and Yorkshire, where all they try to do is to keep foul offensive odors under fair control and prevent pollution of the rivers from increasing. All their clean waters are up in the highland district. They have allowed their main streams to get so overloaded with sewage that they can not get the towns and mill owners to spend the amount of money that they could probably have gotten if they had started cautiously and progressively 30 or 40 years ago. There has been a constant fight between the people whose money must be spent and those who desire to get the streams in a better condition. Does that cover the general viewpoint?

Mr. MAGRATH. Yes. In that moving forward during the last 20 years in Germany, has it in any way overtaxed the resources of the people to make those extreme changes?

Mr. FULLER. In Germany, no; because they have not gone into sewage purification beyond the screening and sedimentation and opportunities for sterilization whenever they had to do it. They have been more fortunate than in the interior part of England in that their rivers are relatively large and they can avail themselves of this dilution method of sewage disposal, which, I believe, has a great deal of merit, but which, I think, has been very much abused on this side of the Atlantic, particularly in our Eastern States here.

Mr. POWELL. There is one point that is very essential to us, Mr. Fuller, and we would appreciate it if you can throw any light on it. What are the recognized means of sterilizing or disposing of sewage? We have had one method, and that is purification and discharge into a river. Would you mind stating all of them without going too much into detail or noticing insignificant methods, but giving us simply those which are reasonably within our reach?

Mr. FULLER. I carry these four different lines of treatment in mind: First, there is screening; second, sedimentation; third, sterilization with liquid chlorine, which is probably the best thing to use now; and, fourth, filtration for the reduction of dead organic matter.

Mr. POWELL. Are there any methods that are likely to succeed in the way of taking care of the sewage, such as fertilizer?

Mr. FULLER. Not that I know of personally. There is a great deal being done to put that evidence in a more favorable light, and some even think that there will be some success commercially in handling sewage sludge for its fertilizing properties, but I do not know of anything that would now lead me to that conclusion.

Mr. POWELL. You do not think that that is within the region of practicability?

Mr. FULLER. I do not hardly think so.

Mr. POWELL. Take the means of destroying sewage through the medium of covered vats; has that system been a failure?

Mr. FULLER. No; these two-story sedimentation tanks, in the upper compartment of which the sewage is allowed to pass through and deposit its solid matter, and in the lower compartment of which the sludge matters are allowed to be decomposed, I believe are a success. I believe that they have come to stay, and they seem to allow sewage to be clarified with less expense and less annoyance from odor than anything that I would be disposed to recommend on a large scale; that is, they are practical working devices and give satisfactory results at a reasonable cost.

Mr. POWELL. Are they capable of being used in large undertakings?

Mr. FULLER. Yes.

Mr. POWELL. Where are they in operation at the present time?

Mr. FULLER. The largest installation is at Atlanta, Ga. The city has three plants. One has been in service for about 21 months, and one 9 months. I am speaking now of these two-story tanks. I was down in Atlanta last Saturday a week ago. They have had a very striking experience. They have seen the adjoining land increase about fourfold in value since the plant was put under construction. They have no trouble from odors. Some of their acreage property in the vicinity abuts immediately against these beds in which the sludge is dried. There are other similar installations, but the Atlanta, Ga., plant, I think, is the most up-to-date one in the sewage-disposal line; at least among the larger plants.

Mr. POWELL. What is the population of Atlanta?

Mr. FULLER. 175,000.

Mr. POWELL. The system is ample for the requirements of that city?

Mr. FULLER. These three plants will take care of sewage from that community. The community is like many others in our Southern States. The sewer system does not cover the entire area. There are about 30,000 people there who still use dry closets, the contents of which are dumped into the sewers.

Mr. POWELL. In what condition does the sewage emerge from the lower tanks?

Mr. FULLER. From the settling tanks it passes through the sprinkler filters. It is thrown through little nozzles about 10 feet apart and is distributed as a spray over the surface of the stone beds, 6 feet deep. There it is aerated and finally it issues below the filter as a liquid that has no odor at all. It is substantially free from visible suspended matter. It looks a good deal like a swampy water. It has no putrescible odor. You would never guess where it comes from by looking at it.

Mr. POWELL. How about the bacteria; are they destroyed?

Mr. FULLER. They care very little about bacteria down there.

Mr. POWELL. I mean the bacteria of disease.

Mr. FULLER. They do not try any sterilization there. They have some small creeks there and on account of bad odors have been threatened by the riparian owners below the outfall sewers with litigation and suits have actually been filed. That is what brought about the construction of those disposal works at Atlanta.

Mr. POWELL. Are they a source of revenue to the municipality?

Mr. FULLER. No. It costs about $2 a million gallons to operate those works. They have about 20,000,000 gallons of sewage a day, roughly speaking, which would mean about $40 a day.

Mr. POWELL. Is not the waste used as fertilizer?

Mr. FULLER. No; it has almost no fertilizing value.

Dr. STARKEY. Mr. Fuller, in your answer to Mr. Magrath's question, I got the impression that you said European methods, particularly the English method, of sewage purification just dealt with the reduction of organic matter. Now, in the large instance of the Thames, the water of which river, of course, is utilized for drinking purposes, very rigid standards of purification are fixed, are they not?

Mr. FULLER. The sewage going into the Thames above the London intakes is pretty well purified.

Dr. STARKEY. They fix very high standards, do they not?

Mr. FULLER. They try to.

Dr. STARKEY. They do; and they see that those standards are carried out, too.

Mr. FULLER. The effluent from the Hampden plant is very pure, organically.

Dr. STARKEY. Are you familiar with the Kingston plant, which is just below Hampden?

Mr. FULLER. Yes.

Dr. STARKEY. That is a particularly fine affluent, is it not?

Mr. FULLER. Yes; I think it is.

Dr. STARKEY. There the reduction of bacteria is quite perceptible from the original sewage; the bacteria content.

Mr. FULLER. Yes.

Dr. STARKEY. The London waterworks authorities are aiming to get the reduction even greater?

Mr. FULLER. Yes.

Dr. STARKEY. That is all with a view to improving the waterworks plant?

Mr. FULLER. Yes, that is what Dr. Houston is striving to obtain.

Dr. STARKEY. Do you not think there must be some real justification for that; otherwise, they would not adopt such stringent measures?

Mr. **Fuller**. Well, their works and intakes, of course, are in existence, and they have to do the best they can with them. If they had modern water plants to install now, I think they would look at it quite differently.

Dr. **Starkey**. Do you not think their sand-bed filters are quite up to date?

Mr. **Fuller**. Reasonably so.

Dr. **Starkey**. Well, judging by the work that they turn out, do you know of any better purification sand-bed filters?

Mr. **Fuller**. I think they would do better if they used coagulants, as I know the waters. Of course, the record of the London filters, through the death rate, speaks for itself. I am not trying to belittle the London filters. They do good work, but they could carry a bigger load than they have to carry, as I know the conditions.

Dr. **Starkey**. It is simply with a view to reducing that load that they are willing to go to all this expense?

Mr. **Fuller**. They did not go to that expense themselves. That is, the metropolitan water board does not go to the expense of purifying the sewage in the upper Thames Valley.

Dr. **Starkey**. But the people who are responsible for that sewage do so.

Mr. **Fuller**. Yes; that is true.

Dr. **Starkey**. The case is somewhat parallel to what we have to handle now, is it not?

Mr. **Fuller**. In some ways.

STATEMENT OF MR. EARLE B. PHELPS, OF THE UNITED STATES PUBLIC HEALTH SERVICE, WASHINGTON, D. C.

Mr. **Powell**. Mr. Phelps, what experience have you had as a sanitary engineer?

Mr. **Phelps**. I graduated from the institute of technology at Boston about 15 years ago, and since that time I have been engaged in sewage and water studies. My work has been mainly along the laboratory lines, chemical and bacteriological studies of water and sewage purification, rather than along engineering lines. I was with the State Board of Health of Massachusetts at their Lawrence experiment station for nearly five years, after which, and until last fall, I was at the institute of technology, where I was assistant professor of chemical biology in the department of public health and gave instruction in water and sewage purification. I was in responsible charge of the sanitary research laboratory of that institution, which, for 10 years past, has conducted extensive sewage purification studies. I have had a consulting practice during the past five years and maintained a New York office and have advised and consulted with many cities on matters of water supplies and sewage purification.

Mr. **Powell**. Any large plants?

Mr. **Phelps**. No, sir; I have never constructed any large plants. In 1910 I was retained by the city of New York, together with Col. William M. Black, to make an investigation and report on the discharge of sewage into the New York Harbor, the present and future results of that discharge and remedies, and I have been retained at various times by the cities of Lawrence, Mass.; New Bedford, Mass.;

Providence and Pawtucket, R. I.; Jersey City, Rahway, and New Brunswick, N. J., and Toronto, Ontario. I am now at the Hygienic Laboratory of the United States Public Health Service in Washington and have advisory relations with the extensive river studies that are being made by that service.

Mr. Powell. Well, you have heard the statement given by Mr. Fuller. Do your views accord with his in all the matters to which he has referred? If they do not, please state the points in which you differ from him.

Mr. Phelps. I quite agree with him in his answer to the first question. It is not only impossible to protect waters flowing through populous regions, but I believe it is impossible to safely protect any surface-water supply. The danger is remote, but we have instances right along of typhoid fever epidemics traced to water supplies that come from mountain streams and lakes that are ordinarily above suspicion. I believe, therefore, that all surface streams need some sort of protection against accidental pollution.

Mr. Powell. How could you get that protection in rural communities, Mr. Phelps?

Mr. Phelps. I am rather more favorably inclined toward chemical disinfection methods than Mr. Fuller indicated that he was. I believe that in those cases where pollution is regular but somewhat remote, or where it is more of an accidental character rather than a regular occurrence, and especially in situations such as we have in rural communities with upland waters, chemical sterilization of the water is the most satisfactory method we have and is a necessary safeguard. I believe that in many of our lake cities, where the pollution is constant but rather less extensive than it is in rivers, chemical sterilization is the most satisfactory way of dealing with that rather minor pollution. Where the pollution is more serious I am also highly in favor of chemical sterilization as an adjunct to other purifications works.

Mr. Powell. Chemical sterilization enters into this rapid filtering system, does it not?

Mr. Phelps. No; not essentially as a part of it. That is, coagulation is a different thing. Chemical sterilization is accomplished by means of hypochlorite or liquid chlorine.

Mr. Powell. It is a frequent concomitant?

Mr. Phelps. It is a very frequent adjunct.

Mr. Powell. You would not recommend, then, that any of this drainage from rural communities be attempted to be clarified or sterilized before it enters the stream?

Mr. Phelps. No sir; speaking only of rural communities.

Mr. Powell. You would leave the clarification and sterilization at the intake where the water is being used for domestic purposes?

Mr. Phelps. Yes, sir.

Mr. Powell. We will now pass to the second question. "Is the present degree of pollution of the Great Lakes or their connecting rivers prejudicial to the public health of either country?" You have read the report, have you not?

Mr. Phelps. I have seen the tables of results. That is the essential matter. I believe that under present circumstances there is a degree of pollution which is prejudicial to the public health. In the first place, the water at some of the waterworks intakes is seriously polluted. It may be admitted that purification of that water is possible, but as the conditions exist to-day the public health is suffering from that pollution. I believer, further, that the lake waters themselves are so polluted by the discharge from vessels that the health of persons traveling on those vessels is endangered.

Mr. POWELL. You believe that there are evils which would grow in the future rather than diminish?

Mr. PHELPS. Undoubtedly.

Mr. POWELL. Did you see the tables for the section below Buffalo and for Detroit, for instance?

Mr. PHELPS. Yes.

Mr. POWELL. The water there is very badly polluted, is it not?

Mr. PHELPS. Very badly, indeed.

Mr. POWELL. Can you gather enough information from the tables to say whether or not the effluent of sewage should be purified to a certain extent before it is allowed to go into the river?

Mr. PHELPS. I believe that some measures ought to be taken in both of those cases to improve the situation.

Mr. POWELL. That situation should not be allowed to exist?

Mr. PHELPS. No, sir; especially in view of the fact that those are growing cities, and that the difficulty becomes greater with each passing year.

Mr. POWELL. What would you recommend as remedial measures?

Mr. PHELPS. I concur quite fully with what Mr. Fuller has said about the stages of treatment. Just how far to go in each case I am not able to say. The first, simplest, and cheapest method and the method that gives us the most for our money is screening and sedimentation. I do not know which I would put first—probably screening: and in addition to this there should be chemical treatment and sterilization of the effluent.

Mr. POWELL. Let us get your ideas cleanly cut. In the case of those two large cities you would recommend, first, the sedimentation and screening and also a certain amount of chlorination?

Mr. PHELPS. Yes, sir.

Mr. POWELL. Could you give us any standard of purity to which you would reduce the sewage before you would allow it to go into the stream?

Mr. PHELPS. Any standard should be based upon reasonable practice rather than upon definite results to be obtained. Ordinarily, reasonable and feasible practice brings a certain percentage of improvement in all of those directions. Screens of a certain degree of fineness are feasible and should be resorted to up to a certain point.

Mr. POWELL. From a bacteriologic standpoint, can you give us any standard?

Mr. PHELPS. The same thing applies there. It is possible to get from 95 to 98 per cent of bacterial removal from sewage at a cost that is fair and reasonable to impose upon any community.

Mr. POWELL. I want to get down to the crux of the matter. What would you say would be a reasonable standard at which the water in which the sewage had been emptied should be taken in at the intake for domestic purposes?

Mr. Phelps. I am rather inclined to look at it from the sewage end. I think we should aim to obtain what is a reasonable degree of purification in sewage treatment. If we are going to build tanks and provide the apparatus for that treatment, then it is economy to work that treatment up to a certain point.

Mr. Powell. What point?

Mr. Phelps. On a bacteriologic basis of perhaps 95 per cent for a minimum.

Mr. Powell. That would depend upon the quantity of bacteria or colon bacilli that you found in the effluent. Ninety-five per cent, say, of 100,000 colon bacilli would leave you 5,000.

Mr. Phelps. Yes.

Mr. Powell. The purification of that would be entirely too great a load to throw on the purification apparatus?

Mr. Phelps. Well, we have other agencies provided by nature. That effluent is diluted perhaps a thousand times in the water. That represents only the effluent of the sewage works, and in these cases where drinking water and other water supplies are involved I believe that to be a reasonable requirement for sewage purification.

Mr. Powell. That would be reasonable if there were sufficient dilution; but what I want to get at is in what condition you would say the river water should enter the intake for the purpose of being purified for domestic purposes? Mr. Fuller said about 500 B. coli per 100 cubic centimeters.

Mr. Phelps. I believe my way of procedure would in the cases in point produce a water a good deal better than Mr. Fuller indicated as his upper limit. If we are going to bring about Mr. Fuller's limit it would be as well to get all we can out of our sewage works and produce in this case a much better water. If a reasonable sewage treatment in addition to dilution will not give a safe water for a water filter plant, then some other water supply or additional treatment of the water becomes necessary.

Mr. Powell. In your opinion Mr. Fuller has not put the minimum sufficiently low?

Mr. Phelps. I understood him to make that answer in reply to the question as to what would be an unreasonable burden on the water filter. I believe that was a proper figure given by Mr. Fuller in answer to that question. I was not prepared to give any figure, but on thinking over his figure I believe it is a fair maximum.

Mr. Powell. What am I to understand when you say your opinion of the water differs a little from his? Do you mean that when you have the purification plant in running order that you might as well take advantage of it and reduce the contamination to a smaller minimum?

Mr. Phelps. That is it exactly.

Mr. Casgrain. I suppose you can not fix any precise rule upon this? For instance, the distance between the place where the sewage originates and the intake of a water pipe has something to do with the rule which you would lay down, has it not?

Mr. Phelps. Yes, sir; very much, indeed.

Mr. Casgrain. Take the Detroit River, for instance. On one side of the river there is the sewage flowing from the sewers of Detroit, and then there is another intake pipe in Windsor, a mile or so across. I suppose that the treatment of the sewage would not have to be so intense, if I may use that word, in regard to Windsor as it would be in the case of some place down lower in the river.

Mr. PHELPS. Yes; if I get your point correctly.

Mr. CASGRAIN. For instance, if you were laying down some rule as to the way sewage ought to be treated in Detroit with regard to what happened in Windsor, probably your rule would not be quite so stringent as against Detroit as if you were speaking of the condition in Detroit itself.

Mr. PHELPS. I do not think it would make very much difference. I want to make this point plain, that if we agree, as I believe we do, that those waters are pretty seriously polluted now and that they are going to be more seriously polluted, then there is no better time than the present for taking some remedial steps, and we might as well take advantage of our present knowledge of sewage purification and secure a good result. Perhaps that is a better result than is really necessary to-day, but the difference between a 50 per cent removal of bacteria from the sewage and a 95 per cent removal is a very small matter in cost. It involves the same apparatus and tanks that would have to be used, and it would merely mean some more chemical. A 95 per cent removal can be obtained at a reasonable cost, and I believe that taking into consideration the general benefit to be derived it would be worth the money. We might just as well aim for a high standard. It reduces danger from unforeseen accidents at the water filter and gives us a greater margin to work on.

Dr. STARKEY. Do you consider filtered drinking water containing 1 colon bacillus in 10 c. c. a good brand of water and safe?

Mr. PHELPS. That is a pretty bad place in the scale to ask me about. I should say that that was not ideal. There are many filters that can do better than that. I think if the filtered water were running that way constantly, that is, never exceeding that figure, there probably would not be much typhoid fever contracted from the use of such a water, but I assume that to be the regular performance of the filter. Any filter which is giving that result most of the time would undoubtedly give a worse water a part of the time. I should say that the margin of safety was perhaps a little too small there.

Dr. STARKEY. What would you fix as a bacteria or colon content of a good filtered water?

Mr. PHELPS. For a yearly average?

Dr. STARKEY. Yes. Would you have it 1 in 50 c. c.?

Mr. PHELPS. Somewhere between 1 in 10 c. c. and 1 in 100 c. c.

Dr. STARKEY. Should we take 1 in 100 c. c. as an average between the two?

Mr. PHELPS. I should say that that would be good water.

Dr. STARKEY. I want to get back to the purification. Filters will take an average of 98 per cent of the reduction. So if we get only 95 per cent of reduction and we start with 500 B. coli in 100 c. c., we are going to get 10 B coli in 100 c. c. That is 1 in 10.

Mr. PHELPS. I would not want to go any higher than Mr. Fuller's 500, which I understand to be his conception of an unreasonable burden on a water filter. It is a rather embarrasing point.

Dr. McLAUGHLIN. I have here a list of 14 or 15 plants with the raw water and the result. It might help Dr. Starkey to look at that list.

Mr. POWELL. I guess we had better get them put in as a tabulated statement coming from you, Dr. McLaughlin.[1] Is there anything further, Dr. Starkey?

Dr. STARKEY. No; I think Prof. Phelps does not want to go on record. Your standard of 500 would have to come down somewhere about 100 or 200.

Mr. PHELPS. I have not suggested 500 B. coli per 100 c. c. as a standard. Mr. Fuller gave it as an unreasonable burden. In this I concur. My standard would be placed at the sewage end and would produce in this case, with dilution, a much better result than 500 B. coli per cubic centimeter.

Mr. POWELL. Would not that depend to a certain extent on what the contamination was? If it were off rural land it would stand a much higher percentage. If it were off urban districts it would take a much lower percentage.

Mr. PHELPS. That is my embarrassment. I think it is a little unsafe for a witness to go on record as favoring a certain definite figure without a fuller consideration of the circumstances. I believe it is more of a local matter. I know of some fine, pure waters up in the Connecticut hills in which I would not object to 1 colon bacillus in 10 c. c., but I know from the character of the drainage area that that represents agricultural drainage. I think that in these cases we ought to have a rather strict standard, because we know that most of these coli are from sewage.

Mr. POWELL. We will now pass on to question No. 4:

> On general principles do you consider it safe to discharge crude sewage into waters used as a source of water supply for a municipal water purification plant?

That means to discharge raw sewage or crude sewage.

Mr. PHELPS. That is another question which has to be answered in the light of facts rather than on general principles. The discharge of sewage of a small town into a large river would not impose any hardship upon the water filter of the city below. The discharge from a large city into a small stream would possibly impose a very severe hardship. I believe there is a certain degree of pollution which is permissible and can be readily handled by water filters and should be allowed in our general policy of conserving our resources.

Mr. CASGRAIN. I suppose you will say that it is impracticable to prevent cities from throwing their sewage into the rivers and lakes.

Mr. PHELPS. No, sir; I would not say that. My point is this: We might imagine two communities discharging into the same stream, one with 100 times the population of the other. If the large community purifies its sewage 99 per cent bacteriologically it will place itself exactly on par with the small town which discharges crude sewage. I would look upon one of those as just as serious a matter as the other. In other words, it is a question of the relative size of the community and the stream.

Mr. CASGRAIN. If you were in our position, would you say that we could adopt a rule by which we would prohibit all the cities and towns along the boundary waters pouring their sewage into the rivers and lakes on the boundary?

Mr. PHELPS. In the specific case of the river, I believe you would be justified, because the sum total of the damage is known, and it is known to be excessive.

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[1] Dr. McLaughlin's statement in regard to safe water appears on page 100.

Mr. Casgrain. Well, would it be practicable? Should such an expense be borne by the municipalities, for instance?

Mr. Phelps. I think a great deal of relief could be obtained and a start made in the right direction at a practically feasible cost.

Mr. Powell. Excuse me for boiling your evidence down, Mr. Phelps. You would assent to this: The answer to that question depends, in the first place, on the ratio between the quantity of sewage and the quantity of water by which it should be diluted; and, in the second place, the distance the water would have to travel before it came to an intake?

Mr. Phelps. Yes, sir.

Mr. Powell. I will follow that statement up by this question: Do you know of any ratio between ordinary sewage from a city and water which serves as a dilutor which would be regarded as reducing the sewage to a proper limit? Now, this is outside of the question of the distance it has to run.

Mr. Phelps. That is, you assume a short distance?

Mr. Powell. Yes.

Mr. Phelps. That is a very hard way to put the matter.

Mr. Powell. Well, you have no data that would enable you to answer that question?

Mr. Phelps. No, sir; I would not want to try to answer it.

Mr. Powell. For instance, if the flow of the river were 5,000 second-feet, you have no data from which you could tell how many inhabitants that would accommodate in the way of diluting the sewage to a degree that would be ample and proper for the intake purification below?

Mr. Phelps. I might give an outside limit. Disregarding the time of travel in the stream—that is, allowing for no purification whatever of the crude sewage—a dilution of 15 second-feet per capita would undoubtedly leave a safe water for filtration, and 5 second-feet per capita would probably do so. These are extreme figures, however, and would be reduced materially in practice by the purifying capacity of the stream if some time elapses between the sewage discharge and the intake.

Mr. Powell. Now we will pass to question No. 5:

> In waterways where some pollution is inevitable, and where volume is such that no general nuisance can result, do you consider that proper sewage disposal by dilution represents a natural resource, and that utilization of this resource is justifiable for economic reasons provided that an unreasonable burden or responsibility is not based upon any purification plant and that no other menace to the public health is occasioned thereby?

What do you state in respect to that?

Mr. Phelps. Yes; I believe that we should make the maximum use of our streams for the oxidation of sewage. Nature has provided in those streams a mechanism for oxidizing sewage which is precisely the mechanism we use in artificial purification. It is the same that nature uses on the land for the disposal of waste, and that should be utilized, and not only utilized, but conserved. By overloading that resource we fail to make use of it at all. It can be utterly destroyed by overworking, just as one can overwork a horse; proper utilization of that natural resource does not mean its unrestricted use. It is one of the most important matters we have to study, to conserve, and to develop it to its fullest capacity without doing any damage.

Mr. POWELL. That is, conserve it for economic or financial reasons?

Mr. PHELPS. Yes.

Mr. POWELL. This question seems to be all between two schools of thought. One is that the sewage should be sterilized before it enters the river, and the other is that a reasonable amount of it is not an injury, but a benefit; and you are of the latter school?

Mr. PHELPS. I am not an advocate of rigid laws against all pollution, which may be as illogical as the unrestricted pollution of a stream. In any specific case it is necessary to reach a just balance, conserving the greatest economic advantage consistent with the best interests of public health and with proper æsthatic ideas of decency.

Mr. POWELL. What objection would there be to unreserved sterilization of everything? Would it be too expensive?

Mr. PHELPS. We have got to look at the thing from the point of view of getting the most for our money. It is no use, for example, sterilizing the sewage that is going into New York Harbor. A certain amount of pollution in New York Harbor does no harm. The point has now been reached where we have to do something here, but sterilization is not called for. There is no bacteriologic danger here; it is a nuisance.

Mr. MAGRATH. Regarding your statement with reference to getting the most for your money, is that a sound principle where health is concerned?

Mr. PHELPS. I mean, of course, the most health protective measures. It is just as sound there as it is in business. That is, it would frequently be cheaper for a large city like Pittsburgh to furnish pure water to all the people that are possibly injured by the discharge of sewage into the stream rather than purify her own sewage.

The CHAIRMAN. I understand you to draw a distinction between conditions where the question of nuisance must be dealt with and the question of pure water for domestic purposes.

Mr. PHELPS. Those are distinct questions; yes, sir.

Mr. POWELL. Take the next question:

> What do you consider to be an unreasonable burden to place upon the bacterial purifying capacity of a modern efficient water-purification plant?

That is the old question over again. You would reduce the standard below that spoken of by Mr. Fuller, but you would not say exactly at what place you would place that standard?

Mr. PHELPS. I do not care to say that I would reduce it. I would rather not answer the question in just that way. I think it is a pretty broad question. It seems to me that in any given case we can arrive at an answer by comparing the cost of sewage treatment with the benefits to be derived, those benefits to be expressed in terms of cost of water purification. It may be necessary, as has been suggested, to doubly filter the water supply, and if that is cheaper than the purification of sewage upstream and can be shown to be just as satisfactory, then I would favor such a process, but in the light of our present practice, where double filtration has not been resorted to seriously and under a situation such as we have before us here, I believe that some treatment of the sewage upstream is desirable, even admitting that all the cities on those rivers ought to purify those waters. As to just what load filters can safely take I am not prepared to say. I would not, at least, raise Mr. Fuller's figure.

Mr. POWELL. Have you not some standard in practice that you work up to?

Mr. PHELPS. I know several places that I think are seriously overloaded to-day.

Mr. POWELL. What are they?

Mr. PHELPS. The Merrimack River has been mentioned here to-day in connection with Lawrence. In my opinion that water is not suitable water for filtration by present methods. The upkeep on the filter is high. The responsibility placed upon the filter itself and upon the filter attendants is very great and the margin of safety is small. Little fluctuations are apt to produce bad results. We have one interesting case where the filter went out of commission for a while and we had an epidemic of typhoid. That filter has too great a responsibility; but just where one would place the line I do not know. It is like the difference between a good man and a bad man; one can show examples of each, but it is hard to draw the line between them.

The CHAIRMAN. How does the contamination of the waters of the rivers you have just referred to compare with the contamination of the waters in the Detroit and Niagara Rivers, as shown by the report of the sanitary experts in this particular investigation?

Mr. PHELPS. Perhaps Dr. McLaughlin can better answer that question.

Dr. McLAUGHLIN. The conditions in the Niagara River and Detroit River, of course, vary at different points. There are points in the Detroit River where the pollution is worse even than in the Merrimack River, but taken as a whole the Merrimack is worse throughout the entire stream, and in the Niagara River the same thing obtains. Below the Falls it is badly polluted, but I understand the Merrimack River is very much worse than the Niagara River at any point. I do not remember the figures for the Merrimack River. Do you know, Mr. Phelps?

Mr. PHELPS. I have not seen any for several years. It used to be several thousand B. coli per 100 c. c., but that was by old methods.

Dr. McLAUGHLIN. I think it can be safely said that the Merrimack River water is a good deal worse than the water we have to treat in the Detroit or Niagara Rivers.

Mr. POWELL. Mr. Phelps, we would like you, if you can possibly do so, to be more definite, because the distinction between good waters and bad waters you are drawing is as vague as your reference to the distinction between a good man and a bad man. Is there not some standard that you have in mind and can you not say that if the water is up to that standard it is all right and we can let it go, but should not let it fall below that standard?

Mr. PHELPS. I do not believe the problem itself is quite so definite as that. Starting with a good water to purify, and increasing the pollution, the margin of safety becomes less and less. I believe that even with a fairly large margin of safety many water filters having their bad days, or their attendants not feeling quite up to their usual condition and being a little less careful, there is more or less fluctuation in the output of the filter. The potential danger becomes greater and greater with increasing pollution, and there is a continuous gradation from a perfectly satisfactory water to an unsafe or unsatisfactory one. I do not believe the nature of the problem allows us to say where the safe point ends and the unsafe point begins.

It is a question of relative potential danger which can not be clearly delimited. Any pollution probably means some danger, for the filter may break down completely, but if this is slight we can ignore it. More pollution means more danger, and the best we can do is to allow as wide a margin of safety as possible.

Dr. McLaughlin. I believe we would be justified in not trying to fix that point. The margin of safety means that you have not fixed any point.

Mr. Powell. Making all allowance for a margin of safety, what would you say would be the stage of water which would be the maximum limit of badness, so to speak, which you would throw into a purifying plant? You can approximate it in some way.

Mr. Phelps. I will figure it out in this way for you: Mr. Fuller's 500, for which I am very grateful, taken as a starting point, will give us on a 98 per cent reduction 10 B. coli per 100 c. c.

Mr. Powell. That is 1 in 10.

Mr. Phelps. That is 1 in 10; and that, I should say, is just about the limit.

The Chairman. You mean the limit of safety?

Mr. Phelps. The limit of safety; yes. I would like to see a filter doing much better than that ordinarily.

Mr. Powell. But you would like to see it doing no worse?

Mr. Phelps. I would like to see it doing no worse; there may be some filters doing worse, but those filters are like a bad fire hazard, in that they have a potentiality for harm. They may go bad and if they go bad they will do great harm. It is a measure of an unseen danger that is hard to fix.

Dr. McLaughlin. In the case of the Merrimac River they face conditions which already existed, and they are doing the best they can; but in these Great Lakes waters we have now waters that offer us an opportunity for conservation and give us a very much greater margin of safety.

Mr. Powell. I would like to arrive at some particular standard, if it is possible to do so.

Dr. McLaughlin. I should not think it would be wise to permit these Great Lakes waters to reach a degree of pollution such as we have in many of our rivers.

Mr. Powell. Mr. Fuller gave us his ideas, approximating as nearly as he could. He said it was an idea that was loose in his mind; he could not fix it definitely. Now, I want Mr. Phelps to give us his idea just along the same line. Mr. Phelps, you have made yourself clear; that is, in the case of a bad water you are running the risk of greater danger through imperfect operation of the plant than you would be running in the case of a good water (of the plant being efficiently operated). In other words, if there were any water that slipped through without sufficient purification it would contain a much larger percentage of dangerous elements than would a good water?

Mr. PHELPS. Exactly.

Mr. POWELL. And there is where your difficulty comes in laying down any standard in respect to this matter?

Mr. PHELPS. Yes, sir.

Mr. POWELL. Now, assuming that your plant was fairly well operated, what would you say?

Mr. PHELPS. I am assuming that. I am assuming ordinarily intelligent operation. No filter would be any good if it were not fairly well operated, but I also have in mind the accidents that it is impossible to foresee or prevent. Such accidents happened to the Lawrence filters some years ago when they froze up and a lot of bad water got through, and at Philadelphia where a pipe line burst and some raw water got into the system. These are the things that I have in mind, and also the fact that the operation of the filter is not a steady and constant thing but fluctuates and has a few very bad points and many medium bad points to average in.

Mr. POWELL. Its efficiency is a variable quantity?

Mr. PHELPS. Yes, sir.

Dr. STARKEY. In view of that last statement, does not that rather commit you to the policy of feeding such a filter with a good class of water?

Mr. PHELPS. It commits me to just what I said at the start, that I believe in going at it from the other end and accomplishing all that can be done within reason at a reasonable cost and that would relieve us the burden of fixing any standard at the waterworks. If the water is too bad after that, it will be necessary to get another water supply.

Mr. POWELL. "What do you consider to be an unreasonable responsibility to place upon a modern efficient water purification plant?"

Your answer to that would be the same, I presume, as to the preceding question?

Mr. PHELPS. Yes, sir.

Mr. POWELL (reading):

> Would you consider it proper and advisable to permit the discharge of sewage or sewage effluents under proper restrictive control up to a point where the degree of pollution did not impose an unreasonable burden or responsibility upon purification plants of public water supplies?

Mr. PHELPS. Yes, sir; I would.

Mr. POWELL. Do you wish to enlarge on that in any way? We have had the matter up before with you.

Mr. PHELPS. I think not; only to refer to what I said about natural resources. I believe we should utilize the resources that we have.

Mr. POWELL. It would all be covered by the unreasonable burden or responsibility?

Mr. PHELPS. Yes, sir.

(Note to stenographer: I do not believe Mr. Powell said "expense." If the question is to stand as it is, however, I would answer: "It is not a question of burden of expense so much as a burden which shall preclude efficient purification.")

Mr. POWELL (reading):

> If the discharge of urban sewage was sufficient to render the raw water at the intake in question of such a character as to impose an unreasonable burden or responsibility upon the water-purification plant, would you consider that

> sewage treatment had been carried far enough when the degree of pollution at the intake was reduced below that which constitutes an unreasonable burden or responsibility upon the water-purification plant?

That, I suppose, is a question of condition, is it not?

Mr. Phelps. I can be a little more specific on that.

Mr. Powell. Please do not confine yourself in words, but give us all your views on it.

Mr. Phelps. Such purification is undertaken in certain stages. We can not produce a gradual improvement from nothing up to 100 per cent, but we have to do a certain amount, and that takes us up to a certain point. We can have limited sedimentation, but it does not cost much more to obtain the maximum benefits from sedimentation. We can have sterilization within certain limits, but the same applies there. If we are going to sterlize at all, it does not cost much more, and it is worth the additional cost to obtain a high efficiency. So in answer to this question, I would say that if sewage purification is going to be undertaken, and it is necessary to produce a certain minimum requirement at the waterworks intake, then we might as well continue that process up to a point of efficiency which represents the most good for the money regardless of the fact that perhaps that full efficiency is not quite needed at the present moment in the obtaining of good drinking water.

Mr. Powell. Would not the element of dilution enter into a full answer to that question? If you are dumping your sewage effluent into a great quantity of water, there would be less necessity for purification of the effluent.

Mr. Phelps. That is fixed in this question by the requirement that we must have a certain standard at the water intake, and I assume that the element of dilution and the element of time have already been taken advantage of and that something further is necessary. Now, if we are going to do something further, it is well to utilize the sewage-disposal plant to its maximum efficiency rather than try to keep it down to the minimum.

Mr. Powell (reading):

> Taking it for granted that it is impossible to control surface drainage from the countryside due to rain washings, etc., is it your opinion that modern efficient water-purification plants could adequately cope with this form of pollution?

Mr. Phelps. Yes.

Mr. Powell. You have no hestitation in saying that?

Mr. Phelps. Not at all.

Mr. Powell. That is a much less difficult thing to cope with than sewage from a city?

Mr. Phelps. That is relatively simple; yes, sir.

Mr. Powell (reading):

> Provided the discharge of urban sewage into any part of the Great Lakes or their connecting rivers is such that an unreasonable burden or responsibility is placed upon a water-purification plant, what methods of sewage treatment would you recommend to reduce the pollution to a point where no unreasonable burden or responsibility is placed upon such water-purification plant?

Mr. Phelps. I agree with Mr. Fuller exactly in what he said. It is not worth while to repeat it.

Mr. Powell (reading):

> Even if water-purification plants properly constructed and efficiently operated existed in all municipalities, do you consider that indiscriminate discharge of sewage by vessels should be permitted?

Mr. PHELPS. No; I do not.

Mr. POWELL. For what reasons?

Mr. PHELPS. In the first place, those vessels constitute moving sewers. They are constantly going up and down by the intakes of the water supplies, and they throw or may throw at any moment a rather excessive burden upon that particular portion of water going through. With regard to one another, I think the vessels would have to be considered. I have been looking into this matter and happen to know from correspondence that those lake captains object very seriously to taking water from shore, and one can hardly blame them, since the water from the center of the lake is certainly better than the water at the Chicago intake. As they travel in lanes, they may at any time seriously pollute one another's water supply. I have been working upon remedies for this situation, and perhaps my feeling is engendered by the belief that we have a satisfactory remedy.

Mr. POWELL. What is that remedy?

Mr. PHELPS. A sterlization plant operated by steam which is entirely automatic and can be relied upon. We are trying it out experimentally and hope to place it upon one of the boats this summer. If that remedy works out, as I believe it will, it will be so simple and will satisfy these particular requirements so well and at so little cost that I believe it should be adopted without question.

The CHAIRMAN. The equipment would be on the vessel itself?

Mr. PHELPS. Yes, sir.

Mr. POWELL. Now a few general questions. As respects the means of disposing of sewage, what methods are, in your judgment, the leading ones in the civilized world to-day?

Mr. PHELPS. There are a great many different requirements in that problem and each requirement is met in its own way.

Mr. POWELL. Take the sewage of cities, for instance.

Mr. PHELPS. Even there one can not generalize. There is the requirement, for instance, of very complete purification, such as exists when the amount of dilution water is small compared with the sewage discharge and a serious nuisance would result from the discharge of sewage. That is met best by the old-fashioned sand filter. From that point on there are other oxidizing methods of less and less efficiency, cheaper and cheaper in cost, down to screening, sedimentation, and the mere removal of suspended matter. There is a continuous gradation of method, and I would not say that any one was best except in some particular situation.

Mr. POWELL. What about sewage farms?

Mr. PHELPS. Such farms are used abroad, but are becoming less and less well thought of. I believe they will be abandoned. I think the showing is that there is no profit in them and that probably the cheapest way out is to destroy the sewage by other methods.

The CHAIRMAN. Where are they employed mostly?

Mr. PHELPS. At Berlin and at Paris. At Paris they are being given up. At Berlin I believe they are quite satisfactory. At Edinburgh they have them, and they have been tried in this country. On the Pacific coast they have been fairly successful in irrigating nut orchards. I believe there is a field for such irrigation in the cotton fields of the South to-day.

Mr. POWELL. How about these chemical double-tank arrangements?

Mr. PHELPS. Those perform another function. The septic tank is designed to liquefy the sludge or solid part and to prepare the sewage for purification by the oxidizing filters. It should be regarded in the light of preliminary treatment. I suppose the Imhoff tank may be used as a total treatment. It removes the solids efficiently. It has its field and is a very valuable piece of apparatus for that particular class of work.

Mr. POWELL. How about the comparison between America and the older countries of Europe? Are we on this side of the waters abreast of them?

Mr. PHELPS. I think Mr. Fuller summed that matter up about as I would. We are quite a little ahead of them on chemical disinfection both of sewage and water. I think England is far ahead of us on restrictive control of rivers, but that is more largely because of necessity.

Mr. POWELL. Owing to the density of population?

Mr. PHELPS. Owing to the density of population and the smallness of the streams.

Mr. POWELL. How about the continental countries?

Mr. PHELPS. There is very little to be said one way or the other. In some regions of Germany they have gone into sewage purification rather fully, though, as Mr. Fuller said, their prime object is to get out the solids.

Mr. POWELL. When the conditions in this country, with the large watercourses, are taken into consideration, have we anything to learn from Europe?

Mr. PHELPS Very little, I think.

Mr. POWELL. You think that our systems are better adapted to our conditions than theirs would be?

Mr. PHELPS. It ought to be said in fairness that we have already learned nearly all that we know from them.

Mr. POWELL. The experts in the case of Buffalo—I do not know but what you were one of the gentlemen—were called upon by the city council or the board of health to diagnose the situation there and prescribe for it, and they prescribed a settling tank or sedimentation and screening, but went no further, except to say that possibly chlorination might be resorted to in addition. Now, would you think that if that program were carried out that the situation would be met at Buffalo?

Mr. PHELPS. I think that with chlorination it would probably be met for a good many years.

Mr. POWELL. I have another question to ask you with respect to purification. When you consider the densely populated rural communities along the Niagara River and along the Detroit River and the necessarily large percentage of pollution in the waters there, there would be no object in having the sewage of either Detroit or Buffalo sterilized to a greater degree than would be the water into which it is debauched, would there?

Mr. PHELPS. No; there would be no object, and one could not do it. At best sterilization is imperfect.

Dr. MCLAUGHLIN. I think evidence should be brought out with regard to the cost of sewage treatment in some of the lake cities. I would like to ask Mr. Phelps to give us his views with regard to the cost of sewage treatment in Cleveland or Milwaukee.

Mr. PHELPS. Possibly Mr. Whipple is better informed with regard to Milwaukee. The costs are not excessive, and range for sedimentation and screening perhaps from 10 to 30 cents per capita per annum, and for disinfection 5 cents more. That is a very rough estimate and it is merely to give you my idea.

At Rochester the cost of sedimentation, including an expensive pipe line, was estimated at 28 cents per capita per annum.

At Cincinnati screening, sedimentation, and disinfection were estimated at 29 cents.

Dr. McLAUGHLIN. I want to bring out the point that some lake cities are already going ahead on their own initiative with sewage treatment and are doing it at a reasonable cost. I would like to have Mr. Phelps say something about the advisability of hearings to be held.

Mr. PHELPS. Dr. McLaughlin spoke to me at noon about the hearings on the part of the cities, and I suggested perhaps the commission's next move, before asking the cities to be heard, might be to draft some tentative program to offer to them.

Mr. CASGRAIN. What do you mean by that?

Mr. PHELPS. It seems to me that it is the commission's duty to offer the cities some tentative program on which they are to be heard rather than ask them what they are going to do.

The CHAIRMAN. Are you familiar with the plan on which the commission has agreed under which the investigation of the second branch of this reference is to be conducted?

Mr. PHELPS. I have read the schedule.

The CHAIRMAN. From your knowledge of the plan, what would you say generally as to its advisability or practicability for the purpose of obtaining the information which the commission necessarily must obtain in order to make its reports to the two Governments, together with its conclusions and recommendations?

Mr. PHELPS. I think you have gone about it in a very comprehensive way and wish to offer that single suggestion that some tentative outline regarding purification and protection of the water should be drawn before the cities are heard.

The CHAIRMAN. What would you say as to the commission putting in printed form the proposed plan with the conclusions and opinions of the sanitary experts offered here to-day and submitting that to the cities, together with the announcement that the commission would hear them at a certain time on the question of water purification or sewage treatment, or as to the remedy for the pollution which has been found to exist?

Mr. PHELPS. These gentlemen have been talking in rather broad general terms as a matter of general policy rather than dealing with specific cases. It seems to me it has got to be somebody's duty to formulate this thing in a more specific way. Whether you leave it to your advisers or to Dr. McLaughlin is for you to decide. I fear you will not get very far with hearings with cities on a basis of the kind of evidence that we have been putting in here to-day.

Mr. CASGRAIN. Let us take a concrete case. Is it your opinion that we should go to Buffalo, for instance, with a preconceived plan of what we want Buffalo to do?

Mr. PHELPS. I think so, in fairness to them: otherwise, how can they be heard unless you wish merely to put it up to them what they are going to do.

Mr. POWELL. At present it seems that the pollution extends out into Lake Ontario, for instance, from 15 to 20 miles at the places where there is much discharge of sewage. Now, in view of the probable increase within the next 25 or 50 years of the riparian communities in respect to density of population, might not a time come when this lake would be virtually a cesspool?

Mr. PHELPS. I hardly think it would be so bad as that.

Mr. POWELL. When one gets out 20 miles that is about halfway across.

Dr. McLAUGHLIN. That pollution is only on the surface. That lake is 600 feet deep.

Mr. PHELPS. It will undoubtedly get worse. You can not deny that fact. You can not deny the fact that the longer we wait the harder it is to do anything.

Mr. POWELL. You think measures should now be taken to stop the dumping of their raw sewage.

Mr. PHELPS. Yes; and I think ultimate plans ought to be worked out not only for to-day, but for the future.

STATEMENT OF MR. GEORGE C. WHIPPLE, OF NEW YORK CITY.

Mr. POWELL. Mr. Whipple, will you kindly give us a statement of your experience?

Mr. WHIPPLE. Like Mr. Fuller and Prof. Phelps, I also graduated from the Massachusetts Institute of Technology in Boston. That was in 1889, in the department of civil engineering. Since that time I have been engaged in sanitary work of various kinds related chiefly to water supply and sewerage. After graduation I spent seven years in charge of the laboratory of the Boston waterworks, during which time I had much to do with the sanitary condition of the watershed from which the city of Boston is supplied. Then I came to New York, and for seven years I was in charge of the laboratory of the water supply of Brooklyn, N. Y. After consolidation the functions of this laboratory were extended to New York City. In 1904 I entered into partnership with Mr. Allen Hazen, and since then we have been engaged in business as consulting engineers. We have done a good deal of work in many of the large cities of the country.

About three years ago I became professor of sanitary engineering in Harvard University, and at the present time hold that position and the same position in the Massachusetts Institute of Technology. These two institutions have recently combined, so far as their engineering work is concerned. I am still a member of the firm of Hazen & Whipple. During the last 10 years our firm has had to do with water supply and sewage problems in such cities as Portland, Me.; Boston and Springfield, Mass.; New York City, Baltimore, Washington, and many cities in the South and some of the cities in the West. I take it that you do not care to have a list of all of them. We have also done a good deal of work in Canada. We designed and supervised the construction of the sand filtration plant for the city of Toronto, and are now designing a mechanical filtration plant for the city of Ottawa. A number of years ago I was a member of the water supply commission in the city of Winnipeg. We have done work around the Great Lakes. In 1904 I made an extended examination of the water supply of Cleveland with respect to the quality of the water, and investigated an epidemic of typhoid fever that occurred there about that time, during which there were some 6,000 cases in two or three years. About three years ago I served as a member of the sewerage commission in Milwaukee. I have always had a good deal of an interest in the general subject of lakes and lake currents and the microscopic organisms of lakes, and last year started at Harvard a course in what we call limnology—that is, the scientific study of fresh waters, especially ponds and lakes.

Mr. Powell. You have had an abundance of experience, and such as will satisfy the commission. You have heard the statements of Mr. Fuller and Mr. Phelps to-day. Do you in any important material differ from them in their views?

Mr. Whipple. No, sir: I should say that I am in substantial agreement with what has been said. I might state some of the things differently, but in the main I am in hearty agreement with what was testified to.

Mr. Powell. Now, take the first question:

> Considering drainage from rural communities, agricultural lands, grazing lands, and unsewered towns, especially following rains and thaws, street washings from cities and sewage through storm water overflows, is it possible to maintain waterways draining a populous area in a condition of such purity that they may safely be used as a source of water supply without purification?

What have you to say in respect to that question?

Mr. Whipple. My answer would be, No; that is to say, I am in agreement with what has been already said with regard to that.

Mr. Powell. That is that any stream which flows through a cultivated rural district must be purified before it is fit for a water supply?

Mr. Whipple. Yes, sir. In general, I do not believe that it is wise or safe to furnish a city with a supply of water from a stream draining an inhabited country without first submitting it to some form of purification, unless, as sometimes happens, there is opportunity for very long storage in a lake or reservoir.

The Chairman. A stream draining a rural district?

Mr. Whipple. A stream draining a populous district or even a rural district.

Mr. Powell. A greater portion of the time it might be free from infection?

Mr. Whipple. Yes; it might cause no trouble for several years, and then suddenly there may come a time when infection reaches the water supply, and water takers suffer in consequence. That has been the history of a number of water supplies that could be named. I might mention, for example, Rutland, Vt., a place where they take their water from a mountain brook. They have had a good deal of typhoid there during recent years, some of it apparently caused by this water supply, a supply which most people would think was beyond reproach.

The Chairman. Have they discovered the source of infection there?

Mr. Whipple. Not definitely.

The CHAIRMAN. The origin of typhoid fever is very obscure, anyway, is it not?

Mr. WHIPPLE. Sometimes. It is known, however, that there have been cases of typhoid on the Rutland watershed.

The CHAIRMAN. Are the bacilli of typhoid fever persistent? Will they live long?

Mr. WHIPPLE. No; they do no live long in water. Their life is usually a question of weeks rather than months.

The CHAIRMAN. But they will not live as long as the bacilli of tuberculosis, which live for a long time?

Mr. WHIPPLE. They are, perhaps, somewhat shorter-lived than the tuberculosis germ; but we do not know enough about this matter to make a definite statement.

Mr. POWELL (reading):

> Is the present degree of pollution of the Great Lakes or their connecting rivers prejudicial to the public health of either country?

Mr. WHIPPLE. I agree with Mr. Fuller, that they are not, provided that the water supplies that may be taken from them are purified; but I agree with Prof. Phelps that it may be dangerous to the health of the people if these water supplies are not purified or if the water happens to be used without purification as supplies for the steamers.

Mr. POWELL. I do not want you to go any further than you can go; but I would like to get a fair statement. You have read these tables of the results of the bacteriologic examination last summer, have you not?

Mr. WHIPPLE. Yes, sir.

Mr. POWELL. Taking those and the rivers of Detroit and Niagara, would you not say that the present condition of things as revealed by those tables is one that is certainly prejudicial to the public health of both countries?

Mr. WHIPPLE. In certain places, I should say, yes.

Mr. POWELL. Would you say it is very bad, the condition revealed in certain places?

Mr. WHIPPLE. In certain places, I should say, yes.

Mr. POWELL. Where would those places be?

Mr. WHIPPLE. Along the shores and below the outlets of the sewers.

The CHAIRMAN. To what particular stretches of boundary waters do you refer?

Mr. WHIPPLE. Mr. Powell was referring to the Detroit and Niagara Rivers.

Mr. POWELL. That would be below the cities of Buffalo and Detroit?

Mr. WHIPPLE. Yes, sir.

Mr. POWELL. Did you look at the figures in connection with Rainy River?

Mr. WHIPPLE. I do not remember them specifically. I have not yet had opportunity to study those in any detailed way.

Dr. MCLAUGHLIN. They did not have the report until this morning, Mr. Powell, and have had only a few moments to examine it.

Mr. POWELL (reading):

> Do you consider that unrestricted discharge of crude sewage into the Great Lakes or their connecting rivers should be permitted to continue?

Mr. WHIPPLE. From an administrative standpoint I should say no, yet I think that there are some instances where the discharge of crude sewage into the Lakes would do little or no harm, but it seems to me that from the broad administrative point of view it would be wise to establish the general principle of not allowing crude sewage to flow into the Lakes. The treatment of sewage in some cases may be extremely simple.

Mr. Powell. Take the littoral wash of these Great Lakes. The sewage would hug the shore to a certain extent. Would not that make the conditions of the water such that it should not be used by the riparian proprietors?

Mr. Whipple. Yes; unless these waters are filtered.

Mr. Powell. Certainly. We are considering them in their crude state.

Mr. Whipple. I might add to that that we always have to keep in mind the storm water, and I think that this fact has not been brought out as yet in the testimony of either Mr. Fuller or Prof. Phelps. When we speak of treating the sewage, we seldom mean the treatment of all of the sewage. In certain cities where they have the separate systems of sewage, it is possible to treat all of the sewage, but most of our large cities have the combined system of sewer, and some of the storm water inevitably overflows and reaches the lake without treatment. I do not see how it is possible to prevent such discharge of storm water, or of storm sewage, to use a better term.

Dr. Starkey. Would it be possible to treat that storm water by some form of chlorination?

Mr. Whipple. Of course, it is physically possible to do so, but practically not. I know of no case where it is actually done. Even in England, where attempts are made to give the sewage a pretty thorough treatment, they are in the habit of limiting the sewage treatment to a certain volume represented by five or six times the dry-weather flow.

Dr. Starkey. Where you have a chlorination plant and deal with an average volume of sewage, would it be feasible to have the machinery so arranged as to treat the storm waters by simple chlorination?

Mr. Whipple. I do not think so. For one reason, the storm overflows occur intermittently and at many different places in the system. To disinfect all of the storm sewage would require quite a number of disinfecting plants.

Dr. Starkey. In cases where sewage treatment is being carried out, I presume that the treatment would be applied at one central outfall, and not at a series of outfalls.

Mr. Whipple. That would depend upon the local situation. Naturally, you would attempt to concentrate the works as much as you could for the sake of economical operation.

Dr. Starkey. So that in that case things might be facilitated by chlorination of the whole volume of storm water?

Mr. Whipple. It is my judgment that you can not go very far in treating the storm overflow for the reasons stated. It represents so much sewage. It is just as dangerous as any other sewage, even though it is more dilute. Furthermore, the storm flows often occur at times of high wind and high storm flow so that the pollution that gets into the Lakes at such times is carried farther into the Lakes and may, perhaps, reach some water-works intake more quickly.

That is one of the reasons why I believe it is safer to depend upon the purification of water than upon sewage treatment.

Mr. Powell. Do I understand you to say that the surface drainage of cities is much more polluted than the surface drainage of rural constituencies, as a general thing?

Mr. Whipple. It is hard to say. Yes; in general, I think the surface wash of cities is somewhat more dangerous than the surface wash in rural districts. I would not make any serious point of that, however, because both may be dangerous.

Mr. Powell. The danger from typhoid fever is almost entirely from the excreta, is it not?

Mr. Whipple. Chiefly from human excreta and urine.

Mr. Powell. In cities these would pass into the sewers and would not affect the surface drainage like they would in the country districts?

Mr. Whipple. They might and they might not. There are many cities where there is a good deal of excrement deposited on the ground.

Mr. Powell. Like the case in Baltimore?

Mr. Whipple. Yes; but you do not have to go as far as Baltimore to find nuisances committed.

Mr. Powell (reading):

> On general principles, do you consider it safe to discharge crude sewage into waters used as a source of water supply or a municipal water-purification plant?

Your answer would vary according to conditions?

Mr. Whipple. It would be very largely a question of dilution and time, and by time I mean the period between the discharge of the sewage into the water and the time when that water reaches the waterworks intake.

Mr. Powell. Just give us some idea of that. Take a current moving at 1 or 2 miles an hour. Some of these bacilli live 30 days, do they not?

Mr. Whipple. Yes; probably.

Mr. Powell. That might mean several hundreds of miles that the pollution would have to float along?

Mr. Whipple. The time element is one that involves the rate at which the typhoid bacilli die in water. The mortality is usually large during the first hour and first day and it gradually lessens as time goes on. The fresher the sewage the more dangerous it is.

Mr. Powell. That is, quantitatively it is more dangerous and qualitatively it is less dangerous. The more vigorous ones are the ones that attack the human system more vigorously.

Mr. Whipple. I do not believe that we know enough about the subject to say that.

Mr. Powell (reading):

> In waterways where some pollution is inevitable and where volume is such that no general nuisance can result, do you consider that proper sewage disposal by dilution represents a natural resource and that the utilization of this resource is justifiable for economic reasons, provided that an unreasonable burden or responsibility is not placed upon any purification plant and that no other menace to the public health is occasioned thereby?

Mr. Whipple. I can say yes to that: emphatically, yes.

Mr. POWELL (reading):

> What do you consider to be an unreasonable burden to place upon the bacterial purifying capacity of a modern efficient water-purification plant?

This is the question, Mr. Whipple, on which we required a great deal of light. Can you be more specific than were Mr. Fuller or Mr. Phelps?

Mr. WHIPPLE. I do not think that I can be any more specific than Mr. Fuller or Prof. Phelps have been. I dislike to place a fixed analytical standard for that. While they were testifying I have been thinking over in my own mind another way of approach, and perhaps I might give you the benefit of a few calculations I made while they were talking. The committee appointed by the Secretary of the Treasury a year or so ago has been studying this question of water supply hoping to find a suitable bacteriologic standard for drinking water. This committee, of which I am a member, has not yet made its report; but perhaps I may say that up to the present time the opinion of some of the members has been that it would be wise to place a limit on the number of B. coli at a point which would correspond approximately to about 4 per 100 c. c.

Mr. POWELL. That is 1 in 25.

Mr. WHIPPLE. That would be 1 B. coli in 25 c. c. of water. Now, if we assume that a filter plant removed 97 per cent of the B. coli applied to it there would be 3 per cent remaining in the filtered water, and, consequently, in order to obtain a figure of 4 B. coli per 100 c. c. in the filtered water there must have been 133 B. coli per 100 c. c. in the raw water. That is simply an application of arithmetic. If we were dealing with a filter which removed 98 per cent, then to get our 4 B. coli per 100 c. c. for the filtered water we must start with 200 B. coli per 100 c. c. in the raw water. If we were dealing with a filter removing 99 per cent, then to get our 4 B. coli per 100 c. c. we should have to start with 400 per 100 c. c. Now, you will see that those figures are somewhere near the figures that Mr. Fuller has given; that is, they are just inside of his limit of 500. Then, this thought occurs to me, that when we say 500 B. coli per 100 c. c., are we talking about the average through the year or about a period of a month or a week or a day? It is well known that in raw waters and even in filtered waters there are fluctuations from day to day and even from hour to hour. It seems to me that Mr. Fuller's standard of 500 B. coli per 100 c. c. should perhaps represent the yearly average, and that is doubtless what he had in mind; whereas, an average figure for a month might be less than 500 B. coli per 100 c. c. for the greater part of the year, but occasionally higher.

Mr. POWELL. I suppose that with respect to the drainage on farm land you would not regard 500 B. coli per 100 c. c. as being dangerous?

Mr. WHIPPLE. You would not get that, probably, from drainage from farm land.

Dr. STARKEY. Could you suggest where or how these should be employed to reduce, say, the sewage contamination to that standard? Where would you take your tests, at water intake, or would you take it higher up the river, where the sewage contamination is coming in?

Mr. WHIPPLE. I assumed that this question referred to the water at the waterworks intake.

Mr. POWELL. Yes; because it is thrown upon the machinery there. We will now pass to question No. 8:

> Would you consider it proper and advisable to permit the discharge of sewage or sewage effluents under proper restrictive control up to a point where the degree of pollution did not impose an unreasonable burden or responsibility upon purification plants of public water supplies?

Mr. WHIPPLE. I would say yes to that: provided, of course, that there was no local nuisance involved at the mouth of the sewer.

Mr. POWELL. And provided always that it is good to get it as clear as you can if it does not cost too much?

Mr. WHIPPLE. Surely; that is always a good general principle to follow, to get as much as possible for your money.

Mr. POWELL (reading):

> If the discharge of urban sewage was sufficient to render the raw water at the intake in question of such a character as to impose an unreasonable burden or responsibility upon the water-purification plant, would you consider that sewage treatment had been carried far enough when the degree of pollution at the intake was reduced below that which constitutes an unreasonable burden or responsibility upon the water-purification plant?

Mr. WHIPPLE. I would say yes to that.

The CHAIRMAN. And for the same reasons?

Mr. WHIPPLE. For the same reasons as before, and provided there were no local nuisance involved.

Mr. POWELL. And with the recommendation to get it as good as you can if not costing too much.

Now take question No. 10:

> Taking it for granted that it is impossible to control surface drainage from the countryside due to rain washings, etc., is it your opinion that modern efficient water-purification plants could adequately cope with this form of pollution?

Mr. WHIPPLE. Yes.

Mr. POWELL. But you think it is your opinion that under all circumstances with such waters a purification plant should be resorted to?

Mr. WHIPPLE. Yes, sir; with the few exceptions already mentioned.

Mr. POWELL. Now question No. 11:

> Provided the discharge of urban sewage into any part of the Great Lakes or their connecting rivers is such that an unreasonable burden or responsibility is placed upon a water-purification plant, what methods of sewage treatment would you recommend to reduce the pollution to a point where no unreasonable burden or responsibility is placed upon such water-purification plant?

Mr. WHIPPLE. I think that we should have to look very largely to the method of disinfection of sewage to reduce the number of B. coli and bacteria to the desirable point if we adopt such a criterion as Mr. Fuller suggested.

Mr. POWELL. Would that be in substitution for or in addition to sedimentation and screening?

Mr. WHIPLE. Disinfection would probably be in addition to the screening or sedimentation which for practical and economic reasons would almost always be adopted as preliminary forms of treatment. I would like to bring out this point also, that screening alone does not materially reduce the number of bacteria and sedimentation does not reduce the number by a large percentage. So far as reducing the number of bacteria is concerned, we should probably rely more largely upon disinfection, but, as Mr. Fuller and Prof. Phelps have testified, in the practical construction of works we would probably use coarse screening to remove the coarser matter and some form of tankage to remove the finer material, or perhaps fine screens in lieu of coarse screens and tanks, following this process by disinfection. I think as they did, that in all probability there would be few cases where it would be necessary to use any of the oxidizing processes, such as sand filtration or treatment on sprinkling filters and the like. This is because in the Great Lakes there is abundant oxygen in the water, making it unnecessary to provide it artificially before the sewage is discharged.

Mr. POWELL. There is a feature of the case which you have overlooked and to which I desire to call your attention, and that is that the result of screening and sedimentation is to make much more efficient—or putting it more properly to render necessary a much less amount of chlorination. That is correct, is it not?

Mr. WHIPPLE. That is quite true.

Mr. POWELL. The solid matter takes a large amount of chlorination to purify it.

Mr. WHIPPLE. That is true; and, furthermore, there is some doubt as to whether the disinfecting chemicals get into the heart of the solid particles.

Mr. POWELL. Now, as a matter of economy, taking the cases of Detroit and Buffalo, it is highly desirable, is it not, to have screening and sedimentation there before you apply the process of chlorination?

Mr. WHIPPLE. Yes, sir; probably that is so, but I am not sufficiently familiar with the local conditions. I recommended substantially the same thing to the city of Rochester not long ago.

Mr. POWELL (reading):

> Even if water-purification plants properly constructed and efficiently operated existed in all municipalities, do you consider that indiscriminate discharge of sewage by vessels should be permitted?

Mr. WHIPPLE. No; I do not. I think that from the administrative point of view it would be wise to restrict the danger of sewage from vessels so far as that can be done without too great an expense, yet I agree with Mr. Fuller that the danger to the public-water supply from this source is not great, provided the water supplies are filtered. I regard it, however, as a desirable factor of safety.

Mr. POWELL. That would apply as between the people on the vessels and the people ashore, but how about the people on the vessels *inter se?*

Mr. WHIPPLE. That, of course, is a more direct relation, and that would be another reason why I think that it is desirable to restrict in some way, as far as may be feasible, the discharge of crude sewage from boats.

Mr. POWELL. A question just suggests itself to me at this moment that was made so much of at Buffalo. These lake boats take water ballast, and that ballast becomes very much contaminated in the holds of the vessels, and those vessels spill that ballast out. Would you consider that that is a serious matter?

Mr. WHIPPLE. I suppose it might be under certain conditions, as, for example, where the ballast were taken in where the water was badly contaminated and then discharged at some point near a water-work's intake. I do not believe this would be a serious matter to a city if the water supply were filtered. The situation would be the same as in the case of the sewage discharge.

The CHAIRMAN. But assuming that these vessels do take water ballast in polluted areas, such as harbors, and discharge that ballast in less polluted areas in the vicinity of intakes, would you or would you not consider that a dangerous method?

Mr. WHIPPLE. I should consider it as dangerous in principle, but it strikes me that under most conditions it would not be a very important factor.

The CHAIRMAN. Provided they had a water-purification plant at the intake where the discharge of the water ballast took place?

Mr. WHIPPLE. Yes, sir.

The CHAIRMAN. You spoke of the indiscriminate discharge of sewage from vessels. What would you say about the indiscriminate taking on vessels of water for drinking purposes, as it appears from the investigation vessels do now?

Mr. WHIPPLE. It strikes me as a rather unwise procedure. At the same time I realize that it is likely to be done in spite of regulation.

The CHAIRMAN. The fact that it is, in your judgment, likely to be done in spite of regulation is not a justification for there being no regulation, is it?

Mr. WHIPPLE. Certainly not.

Mr. POWELL. In broad comparisons, what is your view of the relative merits of the United States and European countries with respect to sanitary conditions?

Mr. WHIPPLE. I think that in water purification we are ahead of them in the range of our ideas, but not ahead of them in the way in which we put into practice the ideas that we have.

Mr. POWELL. They work them out better?

Mr. WHIPPLE. They have up to the present time, because they have had more time to do so. I think we are approaching the European condition. In Germany, for example, substantially all surface waters are purified.

Mr. POWELL. In what way?

Mr. WHIPPLE. By sand filtration largely. They also treat their sewage almost universally, but usually the form of treatment employed is very crude. That is, they do not carry the treatment very far. Screening is very largely used in Germany, and short periods of detention in settling tanks. Provision is commonly made for disinfection, but that is not always used. There are not many elaborate works in Germany that are used for treating the sewage of the cities as there are in England. The rivers in Germany flow through much more densely populated regions than those with which we are familiar here. I have recently made some calculations on that point and find that there are large areas in Germany where the population exceeds 400 or 500 persons per square mile, and yet the typhoid-fever death rates in the cities supplied with filtered surface waters taken from these rivers which receive so much sewage are proverbially low, very much lower than the typhoid death rates that we commonly have in our own country. That, it seems to me, is a good argument to show the advantage of a filtered water supply, and the possibility of obtaining a safe water supply from streams that are considerably polluted.

Mr. POWELL. Massachusetts has reached, or at one time had reached, the highest point of excellence in respect to sanitary remedies, had it not?

Mr. WHIPPLE. It was so regarded, certainly by the people of Massachusetts. I am one of these.

Mr. POWELL. Well, it is generally so regarded, is it not?

Mr. WHIPPLE. Yes; I think so.

Mr. POWELL. And we could get as good object lessons there as anywhere else?

Mr. WHIPPLE. Yes; perhaps better than anywhere else in this country.

Mr. GLENN. Mr. Whipple, with regard to these cities we have to look at the cost of this matter. Can you give us any idea of the relative cost of providing adequate remedies without putting too much of a burden upon the communities?

Mr. WHIPPLE. Mr. Fuller has stated that water purification costs something like 30 or 40 cents per capita per annum.

Mr. GLENN. Is that at the intake?

Mr. WHIPPLE. That is the purification of the water taking into account interest charges and operating expenses. Now, that amounts roughly to something over 10 per cent of the total cost of the water, possibly in some cases 20 per cent. The expense of sewage treatment depends very greatly upon the effectiveness of the process, and runs all the way from something less than a dollar per million gallons to $10 per 1,000,000 gallons, or even more. It has always seemed to me that the expense of water purification would be more cheerfully borne by the people than expenses for sewage treatment, because in the one case we are dealing with a service which yields an income, whereas in the other case we are dealing with a service which is usually a direct charge on the taxpayers, and it has been my experience, that when water companies or cities furnish a good quality of water there is seldom any complaint as to high water rates. Most of the complaints of high water rates are in cities where the quality of the water has been unsatisfactory and the consumers take that way of expressing their dislike of the service.

Mr. GLENN. Would not that rate of the lower city be materially lessened if we made the upper city do its part in purifying?

Mr. WHIPPLE. To a slight extent. I think the advantage of treating sewage is more in giving a higher factor of safety than it is in reducing the cost of the water purification process, although even there it may be a slight element in some cases.

Mr. CASGRAIN. In this case the question would be complicated by the fact that we are dealing with two countries.

Mr. WHIPPLE. I recognize that fact.

Mr. POWELL. You have nothing to say about the methods of purifying sewage, as to which is the best and cheapest under ordinary circumstances?

Mr. WHIPPLE. No, sir: I do not know that I have anything to add to what has been said.

Mr. POWELL. You agree with what has been said?

Mr. WHIPPLE. I recognize that there are different methods that are applicable to certain situations, and there is nothing that I could say that would be essentially different from what has already been testified to by Mr. Fuller and Mr. Phelps.

The CHAIRMAN. Mr. Whipple, are you familiar with the plan that the commission has adopted for the investigation of the second branch of this reference?

Mr. WHIPPLE. Yes, sir; in a general way.

The CHAIRMAN. Do you regard it as a practicable plan to be pursued, or have you, as an expert, any suggestions to make whereby that plan could be improved any in order to arrive at correct conclusions and wise recommendations to submit to the two Governments?

Mr. WHIPPLE. I feel that you gentlemen are better qualified to decide upon that than I am. It seems to me that the plan is a good one, and as to the hearings that have been proposed, I think that they would be worth while, but I have a feeling that as Prof. Phelps said, it would be well for you to formulate some general policy beforehand.

The CHAIRMAN. It is the purpose of this hearing to formulate some general policy, based upon fundamental principles, which you gentlemen have brought out.

Mr. WHIPPLE. It seems to me that the next logical step is to present this policy to the different cities that are interested.

The CHAIRMAN. This is a matter of very great importance, not only to the two Governments, but also to the large municipalities that are concerned, and you gentlemen having had much more experience in dealing with the general subject than any member of the commission personally, we desire to get your judgment as to the practicability of the plan which the commission has adopted, or to obtain your views with regard to any amendments to that plan that should be made for the purpose of conducting the investigation of this second branch of the reference.

Mr. WHIPPLE. It seems to me very satisfactory.

Mr. POWELL. Do you know anything about the effect on the fish life by putting sewage into streams?

Mr. WHIPPLE. Yes, sir; to some extent. If you put in too much sewage there is danger that you may kill the fish or at least drive them away.

Dr. McLAUGHLIN. How would the cost of sewage-treatment measures proposed in Milwaukee and those about to be carried out in Rochester compare with the probable cost of treatment which would be necessary under the circumstances existing now in Detroit and Buffalo?

Mr. WHIPPLE. I am afraid that is a question that involves too much detail for me to answer here.

Dr. McLAUGHLIN. I was rather afraid to ask it on that account.

Mr. WHIPPLE. I do not remember at this moment the estimates that were made at either place, but I could look them up and submit them.

Mr. CASGRAIN. If you were charged by competent authority, Mr. Whipple, to go to a city for the purpose of devising some scheme by which that city would do away to a certain extent with bad results which came from throwing sewage into the water, you would go there, I understand, with a preconceived and devised plan beforehand, would you?

Mr. WHIPPLE. If you are speaking about the proposed method of procedure, it does not strike me that I would go there with any detailed plan. It seems to me that that is the function of the local authorities. It seems to me that it would be better to go there more with a statement of what you desire to be accomplished in the way of results.

Mr. MAGRATH. And effect that by diplomatic arrangements with them, you mean?

Mr. WHIPPLE. Yes. It occurs to me that it might be well to have more than one hearing in a particular place. You might first give them your ideas and then a sufficient amount of time for them to digest those ideas and give you the benefit of their views. I might add that it is my opinion that in many cases the treatment of sewage along the lake shore is desirable, and in some cases necessary, for the sake of the cities themselves and to take care of some local nuisance, and that where that is the case a very slight additional treatment would probably take care of the load that might be placed upon water filtration.

Mr. POWELL. The difference between the cost of chlorination and the cost simply of screening and sedimentation is varied is it not? You have the water there in the beds, and as it is let out and passes along the chlorination is very expensive.

Mr. WHIPPLE. It is a small percentage of the total cost.

Mr. POWELL. It does not require much additional plant?

Mr. WHIPPLE. That is true. That is what I had in mind in my last answer.

Mr. MAGRATH. Do you hold that chlorination is not dangerous?

Mr. WHIPPLE. You are referring now to water chlorination?

Mr. MAGRATH. Yes.

Mr. WHIPPLE. I should say emphatically that it is not dangerous to health; it is a benefit. Of course, water may be overdosed or imperfectly dosed. That would cause offensive odors or tastes in the water; but those are not dangerous to health.

Mr. MAGRATH. You think that chlorination is quite harmless?

Mr. WHIPPLE. From a hygienic standpoint, I think it is.

(Thereupon the commission, at 5.30 o'clock p. m., adjourned until half past 9 o'clock a. m. the following morning.)

WEDNESDAY, MAY 27, 1914.

The commission, pursuant to the adjournment, met at 9.30 o'clock a. m.

STATEMENT OF MR. F. A. DALLYN, OF TORONTO, CANADA.

Mr. POWELL. Mr. Dallyn, you have a copy of the questions under discussion before you, have you not?

Mr. DALLYN. Yes, sir.

Mr. POWELL. Will you kindly give us a statement of your experience?

Mr. DALLYN. I am a graduate of the Toronto University, holding degrees in civil engineering and applied sciences from that university. I was for four years in charge of the experimental station attached to the provincial board of health of Ontario, and during the past year have been associated with the provincial government of Ontario as provincial sanitary engineer. In that capacity I am very familiar with practically all the water problems and sewerage problems in the Province of Ontario. The regulations of the Province of Ontario give practically absolute control over those problems to the provincial board of health. Last year I had the honor to act in the capacity of a consulting expert in connection with the field work of this commission in the investigation of the first branch of the reference.

Mr. POWELL. Mr. Dallyn, I call your attention to the first question:

> Considering drainage from rural communities, agricultural lands, grazing lands, and unsewered towns, especially following rains and thaws, street washings from cities, and sewage through storm-water overflows, is it possible to maintain waterways draining a populous area in a condition of such purity that they may safely be used as a source of water supply without purification?

Mr. DALLYN. Mr. Powell, would you be pleased to receive a memorandum regarding the filing of plans of sewerage systems in quadruplicate with the commission?

Mr. POWELL. That is in answer to the first question?

Mr. DALLYN. It is not in answer to the first question, but it is in answer to the suggested procedure.

The CHAIRMAN. If it is your statement, Mr. Dallyn, with regard to the plan of procedure, it ought to go in as a part of that statement.

Mr. DALLYN (reading):

> The passing of such an act would involve the appointment of a permanent staff, under the control of the commission, of three sanitary engineers. It is doubtful whether less than three engineers could give this matter the attention it required. In many instances applications would be received which would require immediate attention. For such municipalities as Detroit and Buffalo the extension work each year would amount to a sum in the neighborhood of $1,000,000. Whether it is advisable to have such detailed information in the hands of the commission is a debatable question. From the detailed knowledge acquired in my position as provincial sanitary engineer for the Province of Ontario—the statutes of which Province require the filing of such plans—I am of the opinion that it is not desirable to require the approval of the commission for such extension. However, it may be advisable for the commission to obtain and, if necessary, require the filing year by year of plans showing the main collectors and interceptors, with careful calculation giving amount of sewage discharged.
>
> The question of extension to existing sewerage systems is quite another matter, and a detail account of it is not of much advantage except as it can affect construction and the finances of the municipalities.
>
> I am of the opinion that this whole matter can be rather simply handled by the passing of legislation making it compulsory to meet with certain requirements and invalidating debentures issued on work not meeting with such requirements; certain clauses to indicate procedure and redress possible to a municipality suffering from neglect of an adjacent municipality which has not lived up to the requirements of such statute. Such a statute would automatically take care of itself, it being in the interests of the constructing parties to comply with it.

Mr. CASGRAIN. You recommend, then, that an act be passed?

Mr. DALLYN. No, sir; I am saying what would be involved in passing such an act.

Mr. Casgrain. By the legislature?

Mr. Dallyn. Yes, sir.

Mr. Powell. Let us take it up in the usual order here, and then those things will come up. Take the first question, Mr. Dallyn, which I have read to you. What have you to say in answer to that?

Mr. Dallyn. Under question 1 you have included the sewage from storm overflows. In my opinion this is not rightly included in the question, since it is entirely a matter of design whether storm overflows become sanitary sewers by discharging a large portion of sanitary sewage or whether they almost absolutely exclude it from the overflows so that they are true storm sewers, not overflow. The question would be more correctly worded by "storm sewers not connected to sanitary sewers," or simply "sanitary sewers." While many municipalities have combined systems, the question as it affects health (re reference) can not be rightly discussed, presupposing such an indefinite condition. Question 1, in my opinion, is not a question which can be rightly answered yes or no. It should be resolved into its several situations, which may be answered by either yes or no.

Mr. Powell. Well, struggle with an answer. So far you are absolutely negative. Give us something definite.

Mr. Dallyn. Where a water front is adjacent to international boundary, protected by breakwaters, with apparently no harbor currents other than those affected by wind conditions, intakes placed with the area protected by the breakwater are obviously subject to pollution.

Intakes carried through such breakwaters by means of special crib section of the breakwater itself and passing out into clear water may be affected by currents due to changes in lake level, issuing from the protected harbor and flowing past the intake. While such currents have usually a definite limitation, their presence even for a short period in the vicinity of the intake may give rise to serious pollution under certain circumstances, such as where the harbor receives the untreated sewage from considerable navigation. The answer then is no; yet if the boat pollution was relieved the answer is probably yes. I have in mind Goderich, for instance.

Mr. Powell. Is Goderich on a river or a lake?

Mr. Dallyn. It is on Lake Huron.

Mr. Powell. What is involved in this first question is not the lake, but watercourses.

Mr. Dallyn. There are practically no watercourses in the limited sense of this question on the international boundary waters at all.

Mr. Powell. Yes; there are. In the first place, there is Rainy River, and there are also the St. Clair River, the Detroit River, and the St. John River.

Mr. Dallyn. But, with the exception of the St. John River, those rivers receive practically no rural pollution.

Mr. Powell. But we are not asking you about that. We are asking you a scientific question.

Mr. Dallyn. I was rather assuming that the question was not scientific, but the answer as you conceive of it is absolutely no.

Mr. Powell. Well, no would be your answer—that is, you would think that a watercourse running through tilled land densely populated would be an unsafe source of water supply taken in its raw condition.

Mr. DALLYN. Surely; but over 80 per cent of the water supplies discussed under the references are not from such situations.

Mr. POWELL. This does not apply to the Great Lakes; it applies to the watercourses. If you will read the question in its entirety you will see what is evidently meant by "watercourses" or "waterways."

Mr. DALLYN. Of course, I am dealing with the situation as it exists. Sarnia does not take its supply from the watercourse; it takes it from Lake Huron. Detroit does not take its supply from the watercourse; it takes its supply from Lake St. Clair. You have practically only three municipalities with a combined population of about 20,000 on the Detroit River taking their supply from that polluted water. Those are Wyandotte, Trenton, and Amherstburg.

Mr. CASGRAIN. What about Windsor and Walkerville?

Mr. DALLYN. The water on analysis is the same as Huron water. It is not subject to rural pollution.

Mr. CASGRAIN. But, as a matter of fact, both Windsor and Walkerville take their water from the Detroit River?

Mr. DALLYN. Yes, sir; its headwaters, to be correct.

Mr. POWELL. Well, there seems to be a general concensus of opinion on that first question. Now we will pass to the second question:

Is the present degree of pollution of the Great Lakes or their connecting rivers prejudicial to the public health of either country?

Mr. DALLYN. I am of the opinion that in answering this question one might safely generalize, and reply unquestionably yes, and in answering yes, I am considering not the water supplies alone, but the heavy pleasure-boat population on those waters which is affected, and which is an international question, and the bathing beaches which are affected, and which is also an international question. The water supplies are only a small factor, in my opinion.

Mr. POWELL. But with respect to the water supplies alone, your answer would be "yes"?

Mr. DALLYN. In some situations, and in others "no." For instance, dealing more directly, Sarnia, Windsor, and Walkerville are not affected by international pollution except as you consider boat pollution as international pollution.

Mr. CASGRAIN. That is, you mean the pollution that is created in Detroit does not extend over the boundary line toward Windsor?

Mr. DALLYN. Not at the vicinity of the intake, nor can it.

Mr. CASGRAIN. I suppose that would be brought out by the examinations which you made this last summer?

Mr. DALLYN. An examination of your progress report reveals that fact very definitely.

Mr. POWELL. In other words, the intermixture of waters does not take place until farther downstream?

Mr. DALLYN. Practically that is true. The other factors do not operate sufficiently to affect it.

Mr. POWELL. Just while we are on that subject there is another question I want to ask you. Do you think, notwithstanding the fact that the central portion of these Great Lakes may not be affected at present by pollution, that it is advisable to allow the raw sewage to be poured into these Lakes?

Mr. DALLYN. That is answered in another portion, sir; but speaking generally it seems inadvisable.

Mr. CASGRAIN. Mr. Dallyn, I suppose that the progress report will show also to what extent pollution extends into the Niagara River to the international boundary?

Mr. DALLYN. That is very clearly shown, sir, at each cross section; the sample points were situated at varying distances from the shore. I would most respectfully like to call your attention, in discussing this question from the waterworks standpoint, to the fact that the municipalities affected on the Canadian side are really very small, and that a per capita expenditure upon them for water purification would be as high, if not higher, than a per capita expenditure upon the American municipalities to institute sedimentation and other preventive measures to limit the extent of the pollution. An improvement of the present conditions would probably not involve them in expensive purification other than the use of chemicals. That is, it would change their estimated per capita expenditure for new works from probably $4 per capita to 75 cents or less, which is a considerable item.

Mr. POWELL. Mr. Dallyn, as you have had a great deal to do with the first branch of the reference, can you give us some idea of where the pollution does affect most prejudicially the public health, or give us a condition which it is reasonable to suppose would affect most prejudicially the public health?

Mr. DALLYN. In the Rainy River you can not distinguish pollution from one side to the other.

Mr. POWELL. What is the cause of that?

Mr. DALLYN. Sewage from both Fort Francis and International Falls.

Mr. POWELL. That sewage enters the river where?

Mr. DALLYN. It enters the river at those points.

Mr. POWELL. Above the falls as well as below them?

Mr. DALLYN. Below the falls and not above, except in the case of some local pollution. The water is so intermingled and the velocities existing are so high where the character of the pollution is the grossest that infected material incorporated in particles may be carried down a considerable number of miles, and, while there are no municipalities of any size until you come to Rainy River, Baudette, and Spooner, that does not say that there will not be, and at those places they are suffering from a bad water, due to the presence of the pollution that has been added above.

Mr. POWELL. Water in its raw condition is not safe to drink?

Mr. DALLYN. No, sir; not with a prevalence of typhoid.

Mr. POWELL. Now leave Rainy River and come east. The next water course is what?

Mr. DALLYN. The next water course is the St. Marys River.

Mr. POWELL. What about that?

Mr. DALLYN. The sewage of these municipalities does not affect each other, but affects navigation for a distance of some 30 miles, and affects a heavy summer population residing on the islands in the vicinity. Those people are not accustomed to filtering their water, and upon them the burden of filtering their water in some cases is considerable, involving a per capita expenditure of as much as $50.

Mr. POWELL. Now hit the evil. Is the water polluted to an extent that renders it unfit for drinking purposes?

Mr. DALLYN. Unquestionably.

Mr. POWELL. That is below the rapids until it enters Lake Huron?

Mr. DALLYN. I would not say until it enters Lake Huron. That is a distance, I think, of over 100 miles.

Mr. POWELL. Now, travel east again and come to the outlet from Lake Huron.

Mr. DALLYN. That is the St. Clair River. The pure lake water does not intermingle with the sewage from Port Huron and Sarnia until you get below the water supplies of the two towns. Below that we have no Canadian water supply. We have found from experience that it is most inadvisable to use the St. Clair River water, and the small municipalities—Courtright, Corunna, etc.—are struggling with deep wells, the use of which is costing them considerable money. The pollution existing in the river is, however, according to the standards given by the preceding gentlemen, practically equivalent to the water you would get from a filter struggling with bad water; that is, about 10 B. coli per 100 c. c. So far as an examination of an individual sample is concerned, you could not distinguish one from the other, although the infectivity is higher from St. Clair water than it is normally from a filtered water.

Mr. POWELL. How about Lake St. Clair?

Mr. DALLYN. Lake St. Clair does not come within this class of polluted waters at all; that is, it is better than the standard you would get from a filter handling a bad water. A filter operating at Amherstburg under present conditions could not deliver water as good as is existing in the upper waters of the Detroit River—that is, bacteriologically, and that is your only way of measuring it.

Mr. POWELL. I meant to ask the experts yesterday a question simply to clear matters up, and overlooked it. I will now ask you that question, Mr. Dallyn. Where you speak about the product of a filter, is your attention centered simply on the process of filtration or the process of filtratiton plus chemical purification?

Mr. DALLYN. I have in my own mind a very grave objection to the use you make of that term.

Mr. POWELL. I am speaking about the results of filtration.

Mr. DALLYN. You can discuss purification; and if you ask me if an engineer can purify sewage and deliver it as a potable drinking water, I would say yes, he can.

Mr. POWELL. You are off on something else. It was stated that in the process of purification there was ordinarily how much per cent removal?

Mr. DALLYN. It varies between 97 and 99.4 per cent.

Mr. POWELL. Now, when you make that statement, are you speaking simply as a result of filtration or of filtration as supplemented by chlorination or other chemical purification?

Mr. DALLYN. When you are designing a building you design it for a load and then consider the safety factor.

Mr. POWELL. Now, you are off on something else again. When you speak about filtration removing 97 per cent of the bacteria existing in it, are you directing your attention purely and simply to the filtration plant without regard to chemical purification or the filtration plus the chemical purification?

Mr. DALLYN. For your satisfaction I would say I was taking it on the purification plant without thought of disinfection.

Mr. POWELL. Without chemical assistance?

Mr. DALLYN. Without chemical assistance.

Mr. POWELL. Now, just there. With chemical assistance can you not have an almost absolutely pure product; that is, bacteriologically speaking?

Mr. DALLYN. Without filtration and the use of chemicals alone you can get the same results. I mean you can get any result by the use of chemicals.

Mr. POWELL. By the use of chemicals you can get absolute purity bacteriologically?

Mr. DALLYN. Exactly; but you have not got a protection.

Mr. POWELL. Now, you are off on something else. Do not get in your mind that we want enlightenment on other subjects. When you speak, then, of purification by process of filtration you are eliminating entirely the chemical element in that statement?

Mr. DALLYN. I am considering what I call purification from a public-health standpoint.

Mr. POWELL. There are two kinds of purification, Mr. Dallyn. There is purification by filtration—a pure, simple, unadulterated process—and there is purification chemically and by the combination of these two methods. When you speak of the purification amounting to about 97 per cent or upward bacteriologically, are you speaking of filtration pure and simple or filtration in combination with sterilization chemically?

Mr. DALLYN. I answered that question by saying that I was considering filtration.

Mr. POWELL. Pure and simple filtration?

Mr. DALLYN. Yes, sir.

Mr. POWELL. Then, notwithstanding that your filtration process might give you that, you would go further and by the assistance of a little chemical make it absolutely pure bacteriologically?

Mr. DALLYN. Lately we have been in the habit of using disinfection to increase the safety factor. Unfortunately, a new practice has crept in, and that is my reason for objecting to your question. Since the use of disinfecting chemicals has generally been adopted the efficiency of filter plants has, through neglect, materially decreased; that is, they now operate their filter plants as a screen and not as a filtration for protection against pathogenic organisms, and their filtration, instead of doing 99 per cent, as is the case in Europe—the efficiency is now around 80 per cent, because they are relying on the chemicals altogether. It is cheaper to do without coagulant than it is to operate a proper filter unit; and then the use of a disinfectant as a protection is convenient. I would like to raise another point here. Mr. Whipple and Mr. Fuller have both had a very large experience on these inland waters with regard to filtration. Their experience does not extend to the filtration of almost pure, clear waters as we have existing in the Great Lakes basin. There are no purification units existing there with the exception of Toronto. Toronto has been unsuccessful in getting a water fit for domestic consumption, without the use of chemicals, by simple filtration. That is, we have a new problem not covered by existing experience in filtering the Great Lakes waters. Toledo has a plant, but they are filtering the Maumee River water and not the water of the Great Lakes.

Mr. POWELL. While we are on that subject we may as well exhaust it. Will filtration purify water chemically as well as bacteriologically?

Mr. DALLYN. You would have to enlarge on filtration. Do you refer to the ordinary slow-sand filtration?

Mr. POWELL. Yes.

Mr. DALLYN. It is not conceded to. For instance, there may be a color which is due to matter in suspension different from true color, and it will remove the major portion of that color and improve the appearance of the water. If it is due to matter in solution it will not affect it at all. It may affect taste to some extent. The mechanical type of filter, however, improves the water from a physical standpoint. Chemically it adds new elements to the water. I am arguing this from my own experience in observing the operation of these units. They are badly operated. We have few large municipalities in Ontario on the international boundary waters that can afford a very heavy staff to oversee water purification operations.

Mr. POWELL. Then, as a matter of fact, filtration is not relied on to purify water chemically?

Mr. DALLYN. Absolutely not, except if you have color, and then you use the mechanical filtration.

Mr. POWELL. I mention a peculiar fact that may be interesting to you all. On the north shore of New Brunswick there is a seacoast of about 60 miles where the action of the waters of the Gulf of St. Lawrence has thrown up what is known as a beach, a series of sand dunes, and inside there are lagoons. This is all intensely salt water, and notwithstanding the fact that nature has thrown up this large ridge, between the salt waters you can detect anywhere within 200 or 300 feet in that sand from the shore a good, fresh water. Is that the result of filtration?

Mr. DALLYN. I would be rather inclined to say no, sir.

Mr. POWELL. Filtration has nothing to do with that?

Mr. DALLYN. I question it. Of course, one would have to examine the situation to answer the question properly. It is probably due to springs. It may be due to rain.

Dr. MCLAUGHLIN. I would like to ask Mr. Dallyn just why slow-sand filter units are not efficient at Toronto. Is it because of the character of the water they receive, or inefficient operation?

Mr. DALLYN. I did three years of work on an experimental unit on that Toronto situation to try and solve that question, not especially with reference to Toronto, but the general problem of handling bad waters on slow-sand filters, and I found that, due to the very clear character of the water, you did not get that growth on the surface of the filtered sand which we get in handling a water either having a high pollution or a water receiving considerable drainage, and that in the case of a sudden infection it came through the filter almost in the same quantities that existed on top. I do not say that it has the same infectivity, you understand, but as far as B. coli detection goes they can be almost as easily detected in the same quantities in the filter effluent as on top of the filter. The infectivity in those waters lies very largely in matters in suspension.

Dr. MCLAUGHLIN. You think there is a failure due to the absence of a schmützdecke?

Mr. Dallyn. I think it is the surfaces down through the filter that are affected and not the schmützdecke, which is a mud deck on the top of the sand.

Mr. Powell. We will now pass to question No. 3:

> Do you consider that unrestricted discharge of crude sewage into the Great Lakes or their connecting rivers should be permitted to continue?

Mr. Dallyn. Considering the extreme pollution which exists at some centers where population is densest and the reasonable anticipation of growth in other centers not at the present time densely populated, it seems most advisable that restrictive legislation be immediately passed in order that this question of pollution may be controlled and that assistance may be secured for its ultimate satisfactory solution.

The further question of economical construction enters in here and it is unquestionably true that judicious control will effect considerable economy in conforming at a future date with an ultimate requirement. I would like to mention in that connection that it is going to be to the economic advantage, in connection with this extension work, for many of these municipalities to entirely separate a storm water from the sanitary sewage.

Mr. Casgrain. For my own information, I would like you to explain what you mean there. I do not understand it at all.

Mr. Dallyn. What I mean by storm water?

Mr. Casgrain. Yes; the distinction that you make there.

Mr. Dallyn. The sanitary sewage, as I consider it, is the flushings from the conveniences placed throughout various dwellings and hotels, and includes kitchen wastes. The storm sewage refers directly to the water, the run-off from rain. If the topography of the land is such that this water comes to your drainage system very fast it floods existing small systems. In other districts, where the ground is very flat, it reaches it slowly and you can handle it with a small system. That is, the question of storm sewers is a special question with each municipality.

Mr. Casgrain. It is an adjunct to the system, is it not?

Mr. Dallyn. No; it is a special thing entirely. That is, you can do without a storm system and flood your streets.

Mr. Casgrain. But a better system would have a storm-sewerage plan, would it not?

Mr. Dallyn. It is absolutely necessary in the case of paved cities, especially where we get a heavy rainfall. Sometimes it runs up as high as an inch an hour. Port Arthur is one place where they are separating and where they find it to advantage. London is another case where the separation of the two is being adopted. One of the annoying factors is that owing to lack of foresight the plumbing by-laws have permitted the entrance of rain water from the roofs into existing sanitary systems and a storm sewer can not take advantage of those connections because it has to replace the whole connection between the house and the street and also install new fixtures. If you gentlemen made a finding, you would affect the by-laws in connection with the handling of rain water. That is the point I am making. You have got to go beyond present conditions in order to affect future advantages.

Mr. POWELL. Then, to the third question, you would answer "yes" for the present, and you would emphasize and intensify this "yes" with regard to the future?

Mr. DALLYN. No, sir. I would answer that "no" now.

Mr. POWELL. Well, I should have said "no" instead of "yes." You would say "no" at the present time and you would answer increasingly and more emphatically in the negative with regard to the future?

Mr. DALLYN. I may say for your information that if you do not do anything the municipalities are absolutely compelled to do so themselves. You might anticipate them by two years. You will not do it by much more than that.

Mr. POWELL. With increasing population this will be more emphatically so in the future than it is at the present time?

Mr. DALLYN. It is at present an economic advisability on account of the water-front improvement.

Mr. POWELL. Now, with regard to question No. 4:

> On general principles, do you consider it safe to discharge crude sewage into waters used as a source of water supply for a municipal water-purification plant?

Mr. DALLYN. Speaking as a sanitary engineer, there is but one answer on the grounds of prevention or water-borne disease, of hygiene, and of aesthetics; "no."

The financial burden entailed by simple sedimentation which would remove, even in those situations which require least treatment, fully 40 per cent of the gross particles in suspension and, at a reasonable estimate, over 90 per cent of the infectivity, would not be a great burden, and is not beyond the financial capacity of any municipality which is able to afford sewerage. That is, if you take the whole question on a per capita basis, their present expenditure on sewerage system is from $15 to $50 per capita. Chicago shows a cost of $15 per capita for their entire sewerage system. To add purification by sedimentation to that would probably increase the per capita cost by $1, and possibly $2 in some situations where construction is difficult. The larger municipalities will have a less per capita cost for improvement works than the smaller ones, because they can borrow money cheaper and they can handle larger quantities of sewage more advantageously.

Mr. POWELL. You have illustrated your point very nicely; but the question is designed to bring out this: Is it absolutely necessary to prevent crude sewage passing into waters which are used as a source of water supply in connection with the municipality that has a purification plant?

Mr. DALLYN. You want to limit the question entirely to the effect on a purification plant?

Mr. POWELL. No. Is it desirable under any circumstances whatever to allow crude sewage to pass into a stream from which a municipality farther downstream draws its water supply, even granting that that municipality has a purification plant?

Mr. DALLYN. I would rather not limit it just to the purification plant. I would rather take it as the conditions exist.

Mr. POWELL. But this is on the basis, you see, of a purification plant. It is asked in connection with that.

Mr. DALLYN. Yes; but it does not bring out the point quite well. That is, you have absolutely omitted there the tremendous boat population and the bathing beaches there.

Mr. POWELL. Supposing there is not a pleasure craft ever in sight or a vessel ever passing up and down. Here is the condition of affairs: There is a stream running down from one city to another city. The city below has a purification plant. Would you consider it necessary to prevent the upper municipality dumping its sewage into that water at all?

Mr. DALLYN. You can not get away from their dumping sewage in. It is just a question of treatment. They have to have an outlet for the sewage. If you consider the question as one with regard to crude sewage——

Mr. POWELL. We are speaking of crude sewage. The whole question is based on crude sewage.

Mr. DALLYN. One has to go back to the original point that you can handle practically anything on a filter that is properly supervised.

Mr. POWELL. There are some people—we will call them cranks—who say that it is absolutely wrong, under any circumstances, to allow crude sewage to pass into a watercourse from which the riparian owners below draw their water supply. This question is designed to meet that situation. Do you class yourself with those persons or with the others who have answered the question in the affirmative, and who have stated that the water, after the admixture of sewage to a certain degree of pollution, should be screened and subjected to sedimentation and possibly to chlorination?

Mr. DALLYN. I am afraid I will have to be public spirited enough and possibly enough in advance of my age to say that the crude sewage should not be discharged with preliminary treatment. It is a public-health proposition first and last, and it should not be discharged crude with some treatment.

Mr. POWELL. Under any circumstances?

Mr. DALLYN. Under any circumstances. There is no advantage in it, no advantage in any way. You save the municipality probably, according to figures that we have, $1 per capita expenditure. You involve their water front in a lot of fecal matter which damages property to a greater extent than the original total expenditure. Considered on a broad basis there is no question about the thing; crude sewage should not be permitted to be discharged.

Mr. POWELL. Supposing that the ratio existing between the amount of crude sewage and the water with which it intermingled would reduce the resultant to a comparatively harmless condition?

Mr. DALLYN. It is not a good practice to encourage at all, and it is going to make legislation difficult. You have no realization of what it is going to involve you in if you make exceptions of that type.

Mr. POWELL. Then, if I gather what you mean——

Mr. DALLYN. I am on the side of the "cranks." I have reason to believe that I ought to be there from the evidence I have.

Mr. MAGRATH. Do you think the principle that applied to one municipality should apply to another municipality, though the conditions surrounding those municipalities are different?

Mr. DALLYN. It is absolutely the only way that you can get your desired end. I am speaking from an administrative point of view and I know what we can do. I know we can not make exceptions of that type, and there is no advantage in making exceptions.

Dr. McLaughlin. Is it not also true, Mr. Dallyn, that already, without being a serious menace to other municipalities, Milwaukee, Cleveland, Rochester, and Toronto have either installed or planned to install sewage treatment measures, and also the city of New York, not from the point of view of being a menace to other municipalities but for its own interest, finds it economically advantageous to institute such measures at this time?

Mr. Dallyn. I will answer that, Dr. McLaughlin, by saying that owing to the lack of proper surveys the municipal authorities are not aware of the conditions that exist, and when they are properly presented to them they are almost anxious to go ahead and clean the thing up. The harbor commission at Toronto have presented the thing in such a light that there is no question as to its advantage to clean up their water front. Detroit has one of the most disgraceful water fronts on these waters. It is just one mass of fecal matter from where the big sewers discharge right down the water front in and around the slips. It is disgusting, and you can not improve those water fronts until you improve those conditions. That is, you have to keep that suspended matter out. Mr. Phelps and other gentlemen have answered the question very ably. They have gotten behind screening and sedimentation. It may not be necessary to go farther. Mr. Phelps has taken the position that is not assailable at all, but what is involved in that conservation that he alludes to has not been brought out, nor is it now known.

Dr. McLaughlin. Would it not be to Detroit's economic advantage, and disregarding the cities below for the moment, to use a simple treatment as least of the sewage?

Mr. Dallyn. I am not sure as to the dollars and cents basis of the question, but there is no question but that all city planning associations, of which we are beginning to have a few in this country, would answer that question in the affirmative. You may not be able to reduce it to the dollars and cents basis, because you can not bring all the factors into the question.

Dr. McLaughlin. It would be at least desirable?

Mr. Dallyn. I think it is advantageous, but I am not in a position, and I think no one is, to bring all the factors into the question and give a reasonable answer on a dollars and cents basis.

Mr. Powell. Mr. Dallyn, you are familiar with Toronto. There is one fact I wish to bring out in that regard. I may be wrongly informed, but I am advised that Toronto has instituted the purification of sewage through a necessity, because it draws its water supply really from a source that is contaminated by its own sewage.

Mr. Dallyn. That water, with its sources of contamination, Mr. Powell, is several times better than the raw water that your sanitary gentleman yesterday said was fit for a purification plant to handle. Those gentlemen said a filter would handle anything up to 500 B. coli per 100 c. c. The average count at the Toronto filtration intake is not as high as that. Seasonally it is higher, but taking an average it is nothing like it.

Mr. Powell. If there is a particular season of the year when there is a likelihood of gross contamination, sanitary engineers must take that into consideration. Are there not times when the intake at Toronto is very much polluted?

Mr. DALLYN. Unquestionably.

Mr. POWELL. That is due to the action of the winds in driving the sewage over the intake, is it not?

Mr. DALLYN. Well, yes; it is probably due to driving bay water over the intake.

Mr. POWELL. Is not this fact the reason why the city of Toronto has instituted a system of clarification of its sewage?

Mr. DALLYN. I am not in a position to answer that absolutely, but I think if you will analyze the Toronto situation you will find that it is by pressure on account of the harbor conditions and not the water conditions. It is the harbor condition that has initiated the work. The public health question was taken advantage of for that purpose most probably.

Dr. STARKEY. With regard to question 4, Mr. Dallyn, in view of the conditions that you have brought out in connection with the purification of lake water, do you think it advisable to institute purification of sewage?

Mr. DALLYN. I do not quite get your question.

Dr. STARKEY. You said that the filtration of lake water did not give good results.

Mr. DALLYN. Yes; it did not give the same results as to efficiency as you could get on these inland river waters, which almost always carry turbidity.

Dr. STARKEY. Would not you consider that an argument in favor of the necessity of purifying sewage?

Mr. DALLYN. Yes. The thing is perfectly obvious. I would like to make a further statement just here. I was interrupted in my statement with respect to the pleasure craft. We have a residual typhoid in many municipalities that is pretty hard to trace exactly to the water supply, but which is undoubtedly largely due to indiscriminate use of these connecting waters for drinking purposes by uninformed people on pleasure craft. It does not seem to be possible to impress upon them the danger of using such water, and the typhoid in such communities is attributed to the municipal water supply. There is something else which requires correction besides the water supply in these situations in order to eradicate typhoid fever and other water-borne diseases.

Mr. POWELL. We will now pass to question 5:

> In waterways where some pollution is inevitable and where volume is such that no general nuisance can result, do you consider that proper sewage disposal by dilution represents a natural resource and that the utilization of this resource is justifiable for economic reasons, provided that an unreasonable burden or responsibility is not placed upon any purification plant and that no other menace to the public health is occasioned thereby?

Mr. DALLYN. I think, perhaps, I shall have to go beyond the question a little and say that it is not advisable. That is practically as I answered the question before.

Mr. POWELL. You say it is not advisable to dump raw sewage. What would you say to the degree of purification to which sewage should be subjected before it is allowed to go into a river?

Mr. DALLYN. Prof. Phelps brought that question very nicely before you, although probably you did not just get the value of his answer.

He said that any purification works that were instituted would do much more than they were required to do. Their operation would involve a better degree of purification than you wanted for your water-supply conditions.

Mr. POWELL. Would it do chemically?

Mr. DALLYN. Yes; for instance, in the disinfection of sewage. Between no disinfection at all and 90 per cent removal there is probably no difference in the quantity of chemical you have to use. That is, you have to bring the quantity up to a certain point and when it gets to that point it gives you 90 per cent purification or it does not give you anything. I think Prof. Phelps answered that question very adequately.

Mr. POWELL. What have you to say to question 6?—

> What do you consider to be an unreasonable burden to place upon the bacterial purifying capacity of a modern efficient water-purification plant?

Mr. DALLYN. As it is worded, the question is not capable of a scientific answer. It is necessary for the purpose of this question to specify whether efficient water purification involves disinfection in addition to filtration. It is common in these days in popular literature to associate the two and speak of the whole as purification, which in reality is two distinct measures—the use of the one affecting largely the operation of the other. That is, where disinfection is relied upon, it modifies and changes in a large measure the operation of the filter units, or in other words, instead of being double protection, which one naturally assumes, the filter is operated merely as a screen and disinfection is called upon to do almost the entire protection. In almost all of the modern plants if conduct of operation were continued and disinfection eliminated, a most noticeable rise in water-borne disease would, in my opinion, be evidenced. This, I believe, will be corroborated by all municipal officers who are associated with the examination of filter effluents and with the association of typhoid rates with them. Toronto will show an increase of cases of typhoid fever when there is a laxity in their filtration. They have to operate efficiently at all times.

In view of this it seems most inadvisable to report upon what constitutes an unreasonable responsibility. Speaking generally, and possibly within the meaning of this question, I would consider the raw water as one which, in event of interruption of the purification unit due to untoward circumstances, would not give rise to an epidemic of water-borne disease.

Mr. POWELL. That is, you think that the water before it enters the purification plant at all should be in such a condition as to render the purification plant unnecessary?

Mr. DALLYN. No, sir. There is a big distinction between an epidemic and an increase in rate. We would not consider an annual death rate from typhoid of say 30 per 100,000 an epidemic. It would be an undue prevalence of typhoid, but it would not be an epidemic. The total number of deaths to cause such a rate would have to happen inside of a few weeks to be an epidemic. If you interrupted your plant you would probably get 10 cases due to a generally bad condition, that is speaking for large communities like Chicago or Toronto or Cleveland.

Mr. POWELL. Assuming, Mr. Dallyn, that you had absolute control of a municipality which was discharging its sewage into the waters of a river from which the municipality lower down and over which you also had absolute control drew its water supply—what would you consider would be the proper thing to do in respect to the purification of water before it reached the intake at the lower municipality?

Mr. DALLYN. Perhaps I can answer that question from something out of my own practice. We have been forced quite recently to withhold approval of further extensions to the sewerage system of the village of Ford City on the Detroit River on account of the menace to the water supply lower down. We have to assume the responsibility for those conditions. We can not assume a further responsibility. That is, they have to institute purification to some measure.

Mr. POWELL. It may be in the nature of the problem, but it would almost seem—and I am not using this offensively—that you gentlemen are beating about the bush; that you are facing a problem that you do not want to give an opinion on. Here is a practical problem before us: what burden of purification should we throw on the locality that is using the water and what burden of purification should we throw upon the locality that is the cause of the pollution?

Mr. DALLYN. According to the reference, you should not throw any burden upon the municipality purifying the water.

Mr. POWELL. You think that the upper riparian men should be charged entirely with the work of purification of their sewage?

Mr. DALLYN. You have reduced the matter to a question of dollars and cents. Whether you are justified in that or not I do not know.

Mr. POWELL. Leaving out the question of dollars and cents altogether and looking entirely at practical methods of purifying water, can you give us any standard whatever that we should seek to impose upon the lower municipality with respect to purification of its water?

Mr. DALLYN. There is one reason, Mr. Powell, why that standard can not be set. Perhaps that reason has not been brought out yet.

Mr. POWELL. Do you mean to answer "yes" or "no" before you go to that? Can you give us any standard? Can you suggest a standard?

Mr. DALLYN. I have suggested one.

Mr. POWELL. That is very vague for us.

Mr. DALLYN. It is not vague in the minds of the men in those communities with whom you will have to deal. They have a more minute knowledge than you can have presented at such a gathering as this.

Mr. POWELL. Consider a case involving an injured party and a party doing the injury, and assume that you are to adjust the matter. What standard would you have in your mind that you would seek to enforce? What burden would you throw on the offender and what burden would you throw upon the party offended against?

Mr. DALLYN. I will answer that question in the way you want it. It would be absolutely justifiable to remove the suspended matter from the sewage above. It is a question whether screening alone is feasible. Screening, after all, is merely an adjunct to sedimentation. It makes it a little easier to handle your solids in your tanks. It belongs to sedimentation, the removal of particles in suspension. At some places they do it all in one process in the tanks, and in other places they do it in duplicate tanks. By the removal of matter in suspension you eliminate the biggest factor affecting the two municipalities; that is, the carrying agent from one municipality to the other. It has been found that typhoid organisms put in clear water will disappear to the extent of probably 99 per cent inside of three days.

Mr. POWELL. You would, in the first place, compel the upper municipality to remove the solid matter in the sewage?

Mr. DALLYN. Yes, sir.

Mr. POWELL. Would you go further than that?

Mr. DALLYN. It would then depend upon the proximity of the sewage outlet to the water-purification plant below. If they are very adjacent, one would be justified in carrying that sewage outlet below the other municipality; and, in that connection, you have cooperation from the other municipality to make that an economic feasibility.

Mr. POWELL. Supposing that they were not in such close proximity as to admit of that. What would you do then?

Mr. DALLYN. The municipality below would have to filter.

Mr. POWELL. Then you would not impose a greater burden on the upper municipality than the removal of the suspended matter?

Mr. DALLYN. The question can not be answered generally. In our Great Lakes' waters at the present time that is all that is involved. There is one situation where that is a little different. For instance, Detroit, Wyandotte, and Trenton do not come within your field. The situation does not hold in those places. I am of the opinion that they will be supplied with water from Detroit. Amherstburg is not affected to that grave extent yet.

Mr. POWELL. To follow you up: You have given us a statement of what you would require in the first place.

Mr. DALLYN. That is the minimum requirement.

Mr. POWELL. Then you say that what you would require the upper municipality to do would depend upon conditions?

Mr. DALLYN. Yes, sir.

Mr. POWELL. You say, in respect to the condition of proximity, that if they were close together you would carry the sewage below and enter the river below the lower municipality?

Mr. DALLYN. Undoubtedly.

Mr. POWELL. If you could not do that, what would you then do?

Mr. DALLYN. The disinfection would have to be very carefully looked after. That is, they would have to install additional and possibly expensive apparatus to make the thing nearly automatic.

Mr. POWELL. You mean the offending municipality?

Mr. DALLYN. The offending municipality.

Mr. POWELL. You agree, then, with the other experts who were on the witness stand?

Mr. DALLYN. The other experts have taken a very sound position.

Mr. POWELL. That is what I thought, but you apparently differ with them.

Mr. DALLYN. The experts have spoken of the conditions as they generally exist. There are particular situations where those conditions do not apply.

Mr. **Casgrain.** It is a mutual obligation, I suppose? One municipality would have to treat its sewage to a certain extent and the other municipality that takes the water would have to purify its water also to a certain extent?

Mr. **Dallyn.** They would have to purify it for their own protection.

Mr. **Casgrain.** Well, it is a mutual obligation between them, is it not?

Mr. **Dallyn.** I do not know that it is. One has to do it for protection, but whether it is right that he should do it I am not prepared to say.

Mr. **Casgrain.** I do not quite understand what you mean, Mr. Dallyn.

Mr. **Dallyn.** I mean whether the party that is receiving the offense should do the purifying. It is a question of public health and not of equity. You might put it that way. The trouble, in my experience, has been in the difficulty of getting a finding in the courts. One side would take advantage of quibbles and make it impossible to obtain a clear finding. They have a good case, but they can not get a judgment on the case.

Mr. **Powell.** We will now pass to question No. 8:

> Would you consider it proper and advisable to permit the discharge of sewage or sewage effluents under proper restrictive control up to a point where the degree of pollution did not impose an unreasonable burden or responsibility upon purification plants of public water supplies?

Mr. **Dallyn.** Both from an engineering and an economical standpoint there is no other solution of this vexed question than to discharge into the international boundary waters at some point or other the main bulk of the sewage now found therein. The answer to the question is, yes; most decidedly. It being borne in mind, however, that this sewage can, when the situation requires, be rendered physically indistinguishable from water; that is, it can be discharged in a condition in which it is both chemically stable and free from pathogenic organisms.

Mr. **Powell.** Question 9:

> If the discharge of urban sewage was sufficient to render the raw water at the intake in question of such a character as to impose an unreasonable burden or responsibility upon the water-purification plant, would you consider that sewage treatment had been carried far enough when the degree of pollution at the intake was reduced below that which constitutes an unreasonable burden or responsibility upon the water-purification plant?

Mr. **Dallyn.** I am of the opinion that this question must be answered "yes." As to whether one would practically be able to distinguish between such treatment and the treatment advisable for the municipality for their own purposes is a question. In the solution, I am of the opinion that without exception the municipalities will go much further than in the immediate needs of the treaty once the question is up for solution, as very little increase in per capita cost, arising out of conformity to legislation, will provide for the requirements of almost every situation.

In this connection, however, it seems advisable to consider the interests of pleasure craft and bathing beaches situated on these waters, and as to whether they are placed at a disadvantage in making a loose interpretation of question 9.

Mr. POWELL. Question 10:

> Taking it for granted that it is impossible to control surface drainage from the countryside due to rain washings, etc., is it your opinion that modern efficient water-purification plants could adequately cope with this form of pollution?

Mr. DALLYN. You, of course, can not restrict surface drainage. Speaking generally, this drainage does not present a serious menace to public health. There is a possible relation between pollution due to cattle and certain intestinal troubles of children. Any filtration plant would, however, give a protection against the pollution normally found to exist by reason of surface drainage. It is not a serious factor in the eradication of typhoid fever in any sense for these international boundary waters.

There are, of course, certain abuses in this connection which might require action. For instance, it came to my attention during the investigation at the eastern end of Lake Erie that a person by reason of carrying on a business involving the penning of ducks to the number of some 100,000 along the lake shore had seriously polluted the lake waters with their fecal discharges for a distance of some 8 miles and had occasioned a great deal of embarrassment and nuisance at the intake of a water supply located at Angola, N. Y. While this possibly is a matter for the local courts, yet it is a good example of the abuse of a privilege which normally would not occasion any nuisance whatever.

Mr. POWELL. Was that on the Canadian side?

Mr. DALLYN. No; it was on the United States side. It is very adjacent to the international boundary water. I think possibly it would reach the international boundary water in a minor degree. It is in Lake Erie and toward Buffalo.

Mr. POWELL. Question No. 11:

> Provided the discharge of urban sewage into any part of the Great Lakes or their connecting rivers is such that an unreasonable burden or responsibility is placed upon a water-purification plant, what methods of sewage treatment would you recommend to reduce the pollution to a point where no unreasonable burden or responsibility is placed upon such water-purification plant?

Mr. DALLYN. For the purposes of the reference I should advise the commission to bring in a finding involving some efficient form of sedimentation, and disinfection to a degree suitable to the requirements of the situation.

Mr. POWELL. You would not advise the adoption of any other methods of dealing with sewage?

Mr. DALLYN. I do not think that under the present conditions you need go further than that. The municipalities in fulfilling requirements, presuming the requirements are made, will recognize that they may have to go further and will provide for it. That is, they will be prepared, knowing that they may ultimately be required to institute more thorough purification.

Mr. POWELL. From your experience within the past year, Mr. Dallyn, probably you may be able to give us some useful hints with regard to the next question. It is question No. 12 and reads as follows:

> Even if water-purification plants properly constructed and efficiently operated existed in all municipalities, do you consider that indiscriminate discharge of sewage by vessels should be permitted?

You might tell us what experiments or investigation you pursued with respect to these steamboat tracks.

Mr. DALLYN. I should like to answer the question first. You have put that question in a rather difficult way, Mr. Powell. There are two situations on the Great Lakes which do not involve purification, if the boat traffic is eliminated. You have presupposed the installation of a purification plant. A purification plant can take care of boat traffic, but whether you have any right to make them put in a purification plant when the elimination of the major portion of the boat traffic pollution would give them an absolutely pure water, much better than they can realize by purification of existing conditions, I do not know. The filter would just screen out those matters in suspension, which may have an infective action. They would not change the count very much in that water. The water itself is almost sterile, but owing to material in suspension due to passengers it increases the typhoid by a considerable item, probably 20 to 40. I am speaking now of the two Soos.

Mr. POWELL. In which way would the infection spread?

Mr. DALLYN. Practically all those headwaters are still waters; that is, the flow over the falls is by means of a weir. The currents evicting above are not of as high a velocity as the currents due to winds. The pollution there is subject to wind action almost entirely with a convergence at certain points.

Mr. POWELL. And the tracks of these steamers then in a natural condition of affairs remains polluted?

Mr. DALLYN. They remain a serious source of pollution. Your report shows that the conditions at the waterworks intake of Sault Ste. Marie, Ontario, which is entirely due to boat pollution, is as bad as the water some 2 miles below that town due to the sewage of the combined population.

Mr. POWELL. Did you pursue any inquiries in respect to the tracks that are generally followed by the lake traffic going and returning?

Mr. DALLYN. Samples were taken running down the St. Marys River and there was another set taken running down the St. Clair River, and still another set in the St. Lawrence River, all of which evidenced the fact that the pollution in the immediate track of vessels was considerably over the normal in that vicinity.

Mr. POWELL. Did you pursue your investigations into the Lakes themselves?

Mr. DALLYN. The upper end of the St. Marys River, which is practically a lake, opening out into Whitefish Bay, is free from any rural pollution. There is no source of pollution other than that from vessels. We pursued them for 18 miles into clear water in Lake Superior.

Mr. POWELL. Did you find any pollution up there?

Mr. DALLYN. Yes, sir; the pollution has about the same value as you are considering as a properly treated water; that is, it has about 10 B. coli per 100 c. c., or a little less than that. The elimination of that boat pollution would render that water better than the purified water from a doubtful source. The lower end of Lake Huron we pursued out for a distance of about 8 miles.

Mr. POWELL. Did you find contamination there from vessels?

Mr. DALLYN. The same condition existed as in Whitefish Bay.

Mr. POWELL. So that altogether you considered it as really a possibly substantial source of infection?

Mr. DALLYN. There is no doubt about it, and our investigation brought out a point which up to the present time has practically received no consideration whatever, and that is the enormous amount of pollution from these vessels.

Mr. POWELL. Have you any recommendations to make with respect to the remedies which should be prescribed?

Mr. DALLYN. I think Mr. Phelps made a very good answer to your question. We have pursued a policy in respect to Muskoka Lakes traffic somewhat similar to what he gave you, and advocated sterilization by steam. It will not cost very much, and the boats can conform to it.

Mr. CASGRAIN. Is that carried out on the Muskoka Lakes?

Mr. DALLYN. It is supposed to be. They have devices for doing it.

Mr. CASGRAIN. I believe that is the case on Lake Champlain, is it not?

Mr. DALLYN. It is possible. It is quite a nuisance in Muskoka, because the boats on the Muskoka Lakes tie up to wharves which are very adjacent to intakes that are used for small hotels. The water is not purified at many of the small resorts. The same trouble is met with on the St. Lawrence River. There is a very heavy summer population down there, and the pollution existing in the neighborhood of waterworks intakes is too much for them to cope with. It is bound to lead to a considerable amount of typhoid fever and intestinal troubles.

Mr. POWELL. You are speaking now of the vicinity of the Thousand Islands?

Mr. DALLYN. Yes, sir. We made a very extensive study there. We examined many waterworks intakes there, and found them without protection and adjacent to the paths of boats.

Mr. CASGRAIN. What did you say about purifying sewage from boats by steam?

Mr. DALLYN. You will probably recall that in treating milk we pasteurize it. We subject it to a heat that is beyond the thermal point at which the organism that is to be destroyed can live. You can kill practically any pathogenic organism except possibly anthrax by boiling it. If these boats use detention tanks or used the tanks existing now in their holds, and before discharging turned exhaust live steam into these tanks, to raise their temperature, they would effect a very efficient sterilization.

Mr. CASGRAIN. Would that method be very expensive?

Mr. DALLYN. No, sir; it would involve practically no cost whatever.

Mr. POWELL. At what temperature do these organisms die?

Mr. DALLYN. That would be a point upon which you would probably have to have expert opinion. I imagine that your experts would recommend a temperature of not less than 80° C. for about 20 minutes.

Mr. CASGRAIN. What would that be in Fahrenheit?

Mr. DALLYN. About 180° F.; not quite up to the boiling point.

Mr. POWELL. There would be no difficulty in complying with the thermal condition, would there?

Mr. DALLYN. No, sir.

Mr. POWELL. Is there any well-known device that could be used by boats or families so as to purify the water?

Mr. DALLYN. There are many well-known devices, but they cost probably anywhere up to $100, and that is not received with favor by the small families.

Mr. POWELL. They prefer to drink the water?

Mr. DALLYN. They seem to have enough nerve to take the chance.

Mr. POWELL. Are these devices efficient and reliable?

Mr. DALLYN. Yes, sir.

REVISED STATEMENT OF MR. W. S. LEA, OF MONTREAL, CANADA.

Mr. POWELL. Mr. Lea, will you first state your experience?

Mr. LEA. My experience, for obvious reasons, does not cover a very long period; in fact, it is 14 years. During that time, with the possible exception of 10 or 12 months, I have been connected with water supply, sewerage, and general hydraulic projects, partly in the United States, but mostly in Canada. My experience has included design, construction, and to a lesser extent operation. I am a science graduate of McGill University, Montreal, and am at present a partner in the engineering firm of R. S. & W. S. Lea, of Montreal. I was for three years, without discontinuing the practice of my profession, lecturer in municipal engineering in McGill University. I was also for one year lecturer in hydraulics to the graduating mining engineering class. With regard to my earlier training, I was in succession on the staff of the late Mr. Freeman C. Coffin, a consulting sanitary engineer of Boston; Mr. F. A. Barbour, who is at present a consulting sanitary engineer of the same city; and Mr. R. S. Lea, of Montreal. I was for about one year after that in charge of the departments of waterworks and bridges for the city of Vancouver, British Columbia.

Referring now to my experience in that line of work which is of most interest to this commission, I mean the pollution of waters and matters relating to plants for the filtration of water and the treatment of sewage: Until within the last few years about the only consideration that had to be given to such plants as these, in most Canadian water-supply and sewerage works, was in the way of proper provision for their convenient incorporation with the initial installations, when they would be needed. In late years, however, more interest has been taken in this subject, and I have either assisted in or been consulted with respect to the preparation of the preliminary plans and reports on a dozen or more water-purification plants and sewage-treatment works. With the exception of a plant at the city of Medicine Hat, Alberta, one under construction at Edmonton, Alberta, a small sewage-disposal plant in British Columbia, and a water-purification plant in Quebec, these recommendations have not been acted upon as yet. We have lately submitted a report to the city of Montreal on the disposal of sewage from what is known as the Notre Dame des Graces ward. Some years ago, when assistant to the late Mr. Coffin, I was intimately connected with all the work involved in the design of the Norwood, Mass., sewage filtration plant. Some years later I was the representative of Mr. Barbour on the construction of the Fredericton, New Brunswick, water-purification plant, and for the first six months of its operation. I was associated with Mr. R. S. Lea, consulting engineer, and Mr. A. D. Creer, engineer in immediate charge of the preparation of a report on the collection and disposal of sewage from the Burrard Peninsula, including the city of Vancouver, three adjacent municipalities, and covering in all a territory of 100 square miles. The important questions for decision there were the proper points and methods of sewage disposal for the prevention of a nuisance in the tidal waters of Burrard Inlet, in the Fraser River, and the protection of the salmon fishing industry on this river.

Mr. POWELL. Take question 1, Mr. Lea:

> Considering drainage from rural communities, agricultural lands, grazing lands, and unsewered towns, especially following rains and thaws, street washing from cities and sewage through storm-water overflows, is it possible to maintain waterways draining a populous area in a condition of such purity that they may safely be used as a source of water supply without purification?

What have you to say in answer to that?

Mr. LEA. Considering what the wording of the question implies, my answer is "no." There are some special cases of properly patrolled surface-water supplies where unusual natural facilities for sedimentation and storage are available, that appear to be safe and might be mentioned as exceptions; but it has not appeared to me that these cases represent the conditions you have in mind.

Mr. POWELL. You happen to have been connected with what we might call a typical case, one which would come within the scope of question 1, and that is the purification plant at Fredericton. Fredericton is situated on the River St. John, is it not?

Mr. LEA. Yes, sir.

Mr. POWELL. It is some 300 or 400 miles long, with its various branches above Fredericton?

Mr. LEA. Yes, sir.

Mr. POWELL. The territoryy is entirely agricultural, with the exception of the small town of Woodstock?

Mr. LEA. That is true.

Mr. POWELL. There you are met with a condition of affairs that would exactly fill the bill so far as the first question is concerned?

Mr. LEA. Yes, sir.

Mr. POWELL. Tell us what difficulties you found in the water and what you had to do.

Mr. LEA. The supply from Fredericton is taken from the St. John River and they used to have in some years an abnormal typhoid incidence in that city. Typhoid was not epidemic, but rather endemic or chronic there. In 1906 a sewerage system and a water-purification plant were installed the same summer. Previous to that time the sewage was generally disposed of in cesspools. The formation there is somewhat the same as I understand it to be in Baltimore, sand and gravel. Following the installation of these works the typhoid rate dropped right away; it was so reported by the board of health there. They said it had practically disappeared. Now, there were not many sewer connections for some time, and although there may have been some unknown fortunate circumstances that contributed to the result, I do not believe that the fact that the sewerage system was put in was an important factor in the reduction of the typhoid; so that we can hardly escape the conclusion that the water supply of Fredericton before filtration was largely responsible.

Mr. Powell. Tell us what kind of a plant you installed there.

Mr. Lea. It was what we call a mechanical plant, using a coagulant and rapid sand filters. They did not use the hypochlorite at that time, as they did not know about it.

Mr. Powell. So that those filtration plants were not supplemented by any chemical process?

Mr. Lea. Not there at that time.

Mr. Powell. Are you familiar with the subsequent course, the effect of the discharge of the raw sewage into the River St. John upon the riparian communities below?

Mr. Lea. No, sir; I am not very familiar with that. There was some litigation in a way about that very point—that is, about putting the crude sewage in; and, as I remember it, the decision they came to at that time was that they would allow the city to discharge the untreated sewage for two years, to find out from actual practice what the results might be. A hearing was held before the executive of the provincial government, and they reserved the right to force the city to put in a purification plant at the end of that time if they saw fit. I do not believe that they have exercised that right, and I presume that there was no apparent necessity for it.

Mr. Powell. Now, take the second question:

> Is the present degree of pollution of the Great Lakes or their connecting rivers prejudicial to the public health of either country?

Can you say anything from your experience with respect to that?

Mr. Lea. No, sir; I can not from actual experience. I should say from my general knowledge of what must obtain in such a situation that it would be surprising if there were not some points of special hazard prejudicial to the health of both countries.

Mr. Powell. Have you looked over the data as gathered by the commission?

Mr. Lea. I have just looked over it, but the answer that I made is not really founded on that data.

Mr. Powell. Pass to the third question:

> Do you consider that unrestricted discharge of crude sewage into the Great Lakes or their connecting rivers should be permitted to continue?

Mr. Lea. No, sir; I think not.

Mr. Powell. Would you base your answer on considerations of health alone?

Mr. Lea. I am really basing my answer on what I expect to say on the question that is going to follow—that is, as to what sort of raw water we should have—and I believe that the standard I would approve of is higher than could be maintained if the unrestricted discharge of crude sewage was allowed.

Mr. Powell. Now, pass to question No. 4:

> On general principles, do you consider it safe to discharge crude sewage into waters used as a source of water supply for a municipal water purification plant?

Mr. Lea. Having in mind what you mean by that question as you explained it to Mr. Dallyn, I should say yes. You said that "under any circumstances whatever," and I should say that putting it in that light, the answer would be "yes."

Mr. Powell. It is a question that you must answer with respect to the conditions that exist?

Mr. Lea. Exactly; it can not be applied generally.

Mr. Powell. Would you agree with the other experts who have made their statements that the question is wholly one of the ratio between the amount of sewage and the amount of water that may act by dilution?

Mr. Lea. Yes; it is largely that. It is also a function of the time, and I should say, of the velocity. Comparing the two cases of where we have a lake expansion with a very low velocity and a rapidly flowing river there would be more pollution brought down by the rapidly flowing river. In one case there would be considerable sedimentation, whereas in the other case if the velocity were high enough we would not get the benefit of sedimentation. So both time dilution and velocity are factors, I should say.

Mr. Powell. Taking one set of conditions with another, what would your answer be to the general question, that it would be the correct or incorrect thing to discharge crude sewage?

Mr. Lea. I think, Mr. Powell, that the answer to that question would be determined by the standard of the water we should maintain at the water-supply intakes. Questions 4, 6, and 7 really come down to the same thing; that is, the character of the water we should have at the intakes. I think they come down to that finally.

Mr. Powell. In ultimate analysis that is what determines the matter—the condition at the intake?

Mr. Lea. Yes, sir.

Mr. Powell. We will dscuss that matter a little more fully with respect to the unreasonable burden to be imposed. Now, take question No. 5:

> In waterways where some pollution is inevitable and where volume is such that no general nuisance can result, do you consider that proper sewage disposal by dilution represents a natural resource and that the utilization of this resource is justifiable for economic reasons, provided that an unreasonable burden or responsibility is not placed upon any purification plant and that no other menace to the public health is occasioned thereby?

Mr. Lea. In answer to that question I should say that in the present state of the art of sewage purification, yes. What I mean by the "present state of the art" is that the value of this resource per capita or per unit of sewage that can be oxidized in the river waters must depend on the cost of purifying it by artificial processes. It is possible that these may be improved in time. I might refer to a statement that was made by Dr. Fowler, who is an authority on the subject, in an address before the Engineering Society of Liverpool not two months ago. Dr. Fowler is an expert of international reputation in sewage treatment research work. While not his exact words, I think he made a statement to this effect: That he looked forward with a great deal of confidence to the time when it would be possible to completely purify sewage in a tank with a resultant product on the one hand of an inoffensive sludge, suitable for a fertilizer, and on the other hand of a completely purified effluent. I do not think he meant sterilized, but merely purified with respect to its organic matter.

Mr. POWELL. The question as framed, Mr. Lea, and the discussion that we have had so far look only to the discharge of sewage into the stream in relation to a municipality below that has a purification plant. Now, I would like to get your opinion with regard to the riparian residents which may have no purification plant. There may be agriculturalists who draw their water from and whose cattle are supplied with water by the stream.

Mr. LEA. I would have to know the country a little better. I think out West that is a very important consideration, because it is difficult to get water from any source except the rivers.

Mr. POWELL. Take the densely populated agricurtural districts.

Mr. LEA. It does not take a large supply for a private house. I do not think it is of much sanitary interest in connection with the watering of stock.

Mr. POWELL. Is it desirable to have a polluted water flowing by these farms from which the farmers may draw the supply of water that their cattle drink?

Mr. LEA. It is undesirable, but it is really involved in the first question. We have already said that it is impossible to maintain proper drinking water from surface supplies without purification. It is dangerous all the time. If the farmers are situated in a country where they can not get water without going to the river, I think they ought to filter their drinking water for their own protection. I do not think that any degree of sewage treatment can free them of some danger in using surface water. The cost of trying to keep these waters suitable and safe for drinking purposes in their raw state is out of all proportion to the protection afforded.

Mr. POWELL. I am not speaking about purification. I am speaking about the desirability or undesirability of discharging sewage into the stream which intensifies the degree of pollution that would be there by reason of drainage from the agricultural lands.

Mr. LEA. If we can keep the condition of the rivers as good as what I am going to intimate in my answer to the next question, I think that is good enough. It will be quite free from offensive organic matter, and will, I should say, keep the rivers in a much better condition than they have been preserved in the older countries.

Mr. POWELL. You would say it is desirable to restrict the discharge?

Mr. LEA. Always desirable.

Mr. POWELL. This may not be a very serious consideration, but the farmers are entitled to consideration as well as the urban people. Now take question No. 6:

> What do you consider to be an unreasonable burden to place upon the bacterial purifying capacity of a modern efficient water purification plant?

In view of everything that has been said, I want you to come out of the murky atmosphere that naturally surrounds this question and get into the sunlight if you can.

Mr. LEA. In answer to that question I might say that, unlike the rest of the witnesses, I have not had the laboratory experience that is perhaps necessary in this connection, but it appeared to me that the logical way to approach that subject was to first fix in our own minds what was an acceptably pure drinking water, and then, knowing what our filtration plants can do in the way of purification, to work back to what we should have for a raw water at the intake. I may say that I had never considered this question to any ultimate conclusion until I had these questions put before me. I proceeded then as well as I could to collect some data on what might be considered an acceptably pure water. Among these data are the records of analyses for the year 1912 of about 25 water supplies in the United States, including supplies that were not filtered and some that were filtered, both with and without the use of hypochlorite, and some that were treated with hypochlorite only. The average typhoid death rate in those cities during that year was 17 per 100,000, and the occurrence of the bacillus coli in 1 c. c. samples was, I think, 4.6 per cent. Now, it so happens that this is in substantial agreement with the limit that Mr. Fuller set when he limited the colon content of the raw water to 500 B. coli per 100 c. c. That is, if we take the efficiency of the filter plant at 99 per cent, it works out to practically the same result, viz. positive results for B. coli in 5 per cent of the 1 c. c. samples. I may say further that in considering what a filter plant is capable of doing, I considered it in respect to the plant without the use of hypochlorite. I believe that that should be kept and regarded as a factor of safety; that it would be unfortunate if the use of this germicide, as stated by Mr. Dallyn, should result in the provision of less efficient filters, or if we should regard it as a justification for accepting a lower standard for the raw water at the intake.

Mr. POWELL. What objection, if any, is there to the chlorination of water?

Mr. LEA. I do not believe there is any objection to it when used within proper limits.

Mr. POWELL. Does it make the water more unpalatable?

Mr. LEA. I would answer that question by saying that if it makes the water unpalatable it is not the proper thing to use alone. It would be the abuse of hypochlorite that would make it objectionable. With regard to the limit for the colon content of raw water as set by Mr. Fuller I would hesitate to set a limit myself, although frankly I had an idea of something a little less than what he stated; that is, for the particular case of such rivers as the St. Clair and the Niagara. For instance, taking the record of those supplies I spoke of—although I would hardly consider that in itself sufficient data upon which to justify a limit being set—if we follow such data out to a logical conclusion I should say in the rivers which discharge from the Great Lakes the colon bacilli present are truer indication of sewage pollution than in the average water supply. Consequently it does not necessarily follow that the occurrence of B. coli in the general run of acceptably pure drinking waters can be safely adopted as a standard for a filtered water from such rivers as the Niagara, or be assumed as a safe premise from which to deduce a standard for the raw water in these rivers. On the other hand, I do not know whether we would be justified in setting such a limit as that on the St. John River. It seems to me we ought to consider the difference between the normal content of the water before we come to some large sewer outlet and the content of that water after we pass it. There is very little doubt in my mind, though, that if we get a raw water that never contains more than 500 B. coli per 100 c. c. and free from objectionable floating solids we will have a very high type of raw water to deal with.

Mr. Powell. Do you agree with what has been generally stated, that this quetsion depends to a certain extent upon the source of pollution; that 400 or 500 colon bacilli, for instance, in water that has received its pollution from agricultural districts would not be as serious as a much less number of colon bacilli received from the sewage of towns?

Mr. Lea. No, sir; it would not usually be so dangerous. It is a good limit to set. I mean that with the limit set to meet the case of rivers receiving the drainage of the large centers of population, we ought to be on the safe side for those draining rural districts.

Mr. Powell. But you recognize a difference?

Mr. Lea. Yes, sir. We might find water pretty bad where we felt it should be pretty good; I mean pretty bad from the index of the colon bacillus. For instance, I was told only yesterday by an engineer in this city that he had made an investigation on a lake in New York State with the object of running down the prevalence of some infectious disease, and he found strong indications by the ordinary bacteriological test of colon bacilli in the water, and, finally, it turned out that it was due largely to wheat rust around there. He merely mentioned that to show that it was not due to the colon bacillus, although it was something that gave an indication like it. I would hesitate to absolutely set a limit in every case.

Mr. Powell. They struck the same phenomenon in the St. John River, where they traced bacteria which they thought were colon bacilli to the effluent of a starch factory.

Now, pass to the next question, No. 8:

> Would you consider it proper and advisable to permit the discharge of sewage or sewage effluents under proper restrictive control up to a point where the degree of pollution did not impose an unreasonable burden or responsibility upon purification plants of public water supplies?

The answer to that would necessarily be yes, would it not?

Mr. Lea. Yes, sir; I think that follows.

Mr. Powell. Now, pass to question 9.

> If the discharge of urban sewage was sufficient to render the raw water at the intake in question of such a character as to impose an unreasonable burden or responsibility upon the water-purification plant, would you consider that sewage treatment had been carried far enough when the degree of pollution at the intake was reduced below that which constitutes an unreasonable burden or responsibility upon the water-purification plant?

Mr. Lea. Yes. I am taking it for granted in this and in the other questions that measures will always be taken to prevent a nuisance in the æsthetic sense.

Mr. Powell. Question No. 10:

> Taking it for granted that it is impossible to control surface drainage from the countryside due to rain washings, etc., is it your opinion that modern efficient water-purification plants could adequately cope with this form of pollution?

Mr. Lea. Yes, sir.

Mr. Powell. Question No. 11.

> Provided the discharge of urban sewage into any part of the Great Lakes or their connecting rivers is such that an unreasonable burden or responsibility is placed upon a water-purification plant, what methods of sewage treatment would you recommend to reduce the pollution to a point where no unreasonable burden or responsibility is placed upon such water-purification plant?

Mr. Lea. I think I am in substantial agreement with what has been said by other witnesses on that point, except that I would perhaps emphasize the importance of disinfection a little more.

Mr. Powell. That is, you would have, in the first place, screenings and sedimentation?

Mr. Lea. Yes, sir. It is pretty hard to escape some sedimentation with disinfection. There must be a certain detention period. In the case of the interconnecting rivers, particularly since the dilution is so great and the velocity so high, the chief danger lies in recent bacterial pollution. The essential remedy then is disinfection with such clarifying processes as are necessary to effect the desired results with the best economy.

Mr. Powell. Then you would supplement these processes by anything else?

Mr. Lea. The processes of sedimentation and screening?

Mr. Powell. Yes.

Mr. Lea. I do not see how we can escape doing that if we set a limit to the condition of the raw water at the intake, and we find that we can not maintain it without something more.

Mr. Powell. You would supplement that by chlorination to a certain extent?

Mr. Lea. Yes, sir.

Mr. Powell. Would the use of chlorination be much of an additional charge?

Mr Lea. No, sir; not for the cost of the plant. The expense of chlorination is very largely the cost of the chemical itself.

Mr. Powell. That is because you would have the water in a stream to receive the chemical, I suppose?

Mr. Lea. What I mean is that for disinfection only you would have to provide tanks for a detention period of only about half an hour, whereas in the case of sedimentation tanks you would have to provide for a detention period of from one to two hours or more, so that the construction costs are high.

Mr. Powell. With your sedimentation process, where would you apply the chlorination—after the water had left the sediment tanks or the beds, whatever you call them?

Mr. Lea. Yes; usually. For instance, in this plant that I spoke of as having been recommended to Montreal we provide for applying the chemicals after the water leaves the tank and also on entering the tank, just as a matter of experiment to see how it might work out. If the chemical is applied after the sewage leaves the sedimentation tanks, other tanks have to be provided for holding the sewage there for some little time.

Mr. Powell. To provide the facilities for applying the chemical would not involve very much cost, would it?

Mr. Lea. No, sir.

Mr. Casgrain. Have your recommendations in that regard been carried out in Montreal?

Mr. Lea. That report was submitted only about two months ago, and I do not think it has been officially considered.

Mr. Casgrain. The reason I ask the question is that some time ago the water in Montreal had such a bad taste that we could hardly drink it.

Mr. LEA. This plant, even if built, would have nothing to do with that; it is on the Back River.

Mr. POWELL. Now take question No. 12:

> Even if water purification plants, properly constructed and efficiently operated, existed in all municipalities, do you consider that indiscriminate discharge of sewage by vessels should be permitted?

Mr. LEA. I may say, Mr. Powell, that I did not think from the sanitary point of view that this question was so important as it appears to be in the opinion of those who have had an opportunity to study it. I have always considered this objectionable more in the esthetic sense and that the sewage should not be indiscriminately discharged around docks, etc., but I have not considered that it was a very important matter from a sanitary point of view, although I really have not sufficient data to make an intelligent answer regarding that question. I think it would require a lot of investigation to be sure of that.

Mr. POWELL. Well, this refers largely to the great highways to the Detroit River and the St. Marys River. On these great highways there are about 15,000,000 souls, and to give you an adequate idea of the commerce I would state that it is about four times in 7 months what the total of 12 months' transportation is through the Suez Canal. It is the greatest highway of commerce in the world by all odds. So you have not considered the question in view of the magnitude of the problem.

Mr. LEA. No, sir. I may say that having regard to Mr. Dallyn's statement about the pollution at the Soo, I can hardly escape answering the general question in the negative.

Mr. POWELL. Are there any other statements that you wish to make of your own motion in connection with this general question?

Mr. LEA. No, sir; I do not think there are any suggestions that I could make that would add anything to what has already been said.

Mr. POWELL. You think that in prescribing remedial measures it would be unnecessary for us to go beyond screening and sedimentation and chlorination?

Mr. LEA. Not in those waters where the dilution is so great. I do not know what the conditions are in the Rainy River or the St. John River. So far as I have heard the conditions prescribed, I do not think biological filters are needed.

STATEMENT OF MR. T. J. LAFRENIERE, OF MONTREAL, CANADA.

Mr. POWELL. Mr. Lafreniere, you have an official position in connection with the Province of Quebec, have you not?

Mr. LAFRENIERE. Yes, sir; I am the sanitary engineer for the Board of Health of the Province of Quebec.

Mr. POWELL. Will you kindly give us your experience in that line?

Mr. LAFRENIERE. My work for the board consists in going over the plans for water and sewerage systems before they are approved by the board. I recommend the approval of those plans with or without modifications as the case may be. Of course, before the report is made on any water or sewerage proposition an inspection of the water intake or of the location of the sewer outlet is made and the local conditions considered.

Mr. POWELL. What is the population of the Province of Quebec at the present time?

Mr. LAFRENIERE. Probably somewhere around 2,000,000.

Mr. POWELL. It is over 2,000,000, is it not?

Mr. LAFRENIERE. Yes, sir.

Mr. POWELL. And all this territory comes within your jurisdiction?

Mr. LAFRENIERE. Yes, sir.

Mr. POWELL. You are alone in exercising your judgment? You have no helpers and no associates?

Mr. LAFRENIERE. I make recommendations to the board of health, but they are not obliged to approve of them.

Mr. POWELL. But all the technical and scientific work devolves upon you?

Mr. LAFRENIERE. At first.

Mr. POWELL. You have no superior?

Mr. LAFRENIERE. No, sir.

Mr. POWELL. I do not think, in view of that fact, that you need go into any further experience.

Mr. LAFRENIERE. If you wish, I can state briefly my life history, as the others have done. I was graduated at Laval University as a civil engineer. After that I took two years of post-graduate work in sanitary engineering at the Massachusetts Institute of Technology. For a year I have been a lecturer in sanitary engineering at the Montreal Polytechnic Institute, a school similar to the Massachusetts Institute of Technology.

Mr. POWELL. I think the first credentials you have given are sufficient. Now, we will take up these different questions, Mr. Lafreniere. We will take the first one and follow them along in numerical order. What have you to say in answer to the first question, which reads as follows:

> Considering drainage from rural communities, agricultural lands, grazing lands, and unsewered towns, especially following rains and thaws, street washings from cities, and sewage through storm-water overflows, is it possible to maintain waterways draining a populous area in a condition of such purity that they may safely be used as a source of water supply without purification?

Mr. LAFRENIERE. Rivers flowing through agricultural lands as well as draining rural areas and receiving street washings and sewage from cities through storm overflows can not be maintained in such a state of purity that their raw waters may constitute a safe water supply, and all water supplies derived from such rivers should be purified.

Mr. POWELL. Is that all you have to say in answer to that question?

Mr. LAFRENIERE. I think it covers the case fairly well.

Mr. POWELL. Now, take question No. 2:

> Is the present degree of pollution of the Great Lakes or their connecting rivers prejudicial to the public health of either country?

Mr. LAFRENIERE. Judging by the progress report which was sent to me about a week or so ago, wherein it is stated that in the connecting rivers the waters are grossly polluted, that the B. coli content is over 300 per c. c., and that the pollution extends from shore to shore, I would say that such a degree of pollution is detrimental to the health of either country where those waters have to be used as a source of water supply.

Mr. Powell. Question No. 3:

Do you consider that unrestricted discharge of crude sewage into the Great Lakes or their connecting rivers should be permitted to continue?

Mr. Lafreniere. I consider the disposal of sewage by dilution as satisfactory, where the organic or bacterial pollution resulting thereby is not prejudicial to the public health. Of course, to specify in the case of the Great Lakes, I would need to go more deeply into the results of the investigation.

Mr. Powell. And you have not had the data before you for a sufficiently long time to do that, I suppose?

Mr. Lafreniere. No.

Mr. Powell. Question No. 4:

On general principles, do you consider it safe to discharge crude sewage into waters used as a source of water supply for a municipal water-purification plant?

Mr. Lafreniere. It would be preferable that all sewage be treated before being discharged into waters used as a source of water supply, but for economical reasons I believe it is a sound policy to allow the discharge of crude sewage into such waters, provided that the raw water at the waterworks intakes is not made by such discharge of such a nature that modern water-purification plants can not handle it.

Mr. Powell. That matter would have to be decided, then, by the condition of the water at the intake?

Mr. Lafreniere. Yes, sir.

Mr. Powell. Question No. 5:

In waterways where some pollution is inevitable and where volume is such that no general nuisance can result, do you consider that proper sewage disposal by dilution represents a natural resource and that the utilization of this resource is justifiable for economic reasons, provided that an unreasonable burden or responsibility is not placed upon any purification plant and that no other menace to the public health is occasioned thereby?

Mr. Lafreniere. Yes, sir; because it is cheaper to purify water than sewage and because the treatment of sewage in most cases would not remove the necessity of purifying the water taken from such supplies. Of course, that is in general. There might be certain local conditions on the Great Lakes where it might not be so.

Mr. Powell. As an illustration, let us take the Niagara River. If Buffalo were to purify its sewage abosolutely it would not help matters down below, would it?

Mr. Lafreniere. No.

Mr. Powell. Because the water would still be contaminated by the general flow. The sewage which would result in a pure resultant would be contaminated by an admixture generally with the water in the river.

Mr. Lafreniere. Yes, sir; and beside financial reasons for purifying the water, I should think that the municipality would rather have under its own control the protection of its own water supply than rely upon the efficiency of a sewage-treatment plant above.

Mr. Powell. We will now pass on to question No. 6:

What do you consider to be an unreasonable burden to place upon the bacterial purifying capacity of a modern efficient water-purification plant?

Mr. LAFRENIERE. To start with, I would like to consider to some extent what is meant by a modern efficient purification plant; whether it is meant by that only water filtration or water filtration and disinfection combined.

Mr. POWELL. Well, take each.

Mr. LAFRENIERE. In my case I would take each. I would consider chlorination or disinfection to be used only as a margin of safety, and have the raw water at the water intake of such a nature that the plant could purify it or at least reasonably do so. Now, I would say that I would not have had the courage of Mr. Fuller to state definitely a standard. Of course, I was not without having my own ideas as to the way to go at it, which way was explained by Mr. Lea; that is, to study, for example, the typhoid statistics of municipalities where we consider that the typhoid rates are satisfactory, and study those statistics in the light of the water analyses; how much B. coli the water contains and how often and what percentage, and from there, considering the efficiency of the purification plant, determine the condition of the raw water, and rely entirely on the hypochlorite or any other treatment as a margin of safety to take care of the variations in the condition of the raw water. I must say that when we look at the results obtained by chlorination, one might be tempted to make that treatment a part of the plant itself. Of course, on the other hand, when we consider that the purification plant has to deliver a water which must be safe 365 days in the year, and that the health of the community depends upon it, I would rather then consider the treatment only as a factor of security or as a margin of safety. I think the figure given by Mr. Fuller is quite acceptable; maybe not as a minimum, and I would not place it as a maximum, but I would be inclined to place the average somewhat lower, to what extent I am not prepared to say.

Mr. POWELL. Before you would give even an approximation you would want to pursue a series of inquiries which you have not made with that object in view?

Mr. LAFRENIERE. Yes, sir.

Mr. POWELL. Question No. 7 is the same as question No. 6. We will pass now to question No. 8:

> Would you consider it proper and advisable to permit the discharge of sewage or sewage effluents, under proper restrictive control, up to a point where the degree of pollution did not impose an unreasonable burden or responsibility upon purification plants of public water supplies?

Mr. LAFRENIERE. Yes, sir; for economic reasons.

Mr. POWELL. Take question No. 9:

> If the discharge of urban sewage was sufficient to render the raw water at the intake in question of such a character as to impose an unreasonable burden or responsibility upon the water purification plant, would you consider that sewage treatment had been carried far enough when the degree of pollution at the intake was reduced below that which constitutes an unreasonable burden or responsibility upon the water purification plant?

Mr. LAFRENIERE. Yes; but in my "yes" I would like to include that provided a factor of safety has been made to take care of the variations in the efficiency of the filtration plant and also of the sewage treatment plant.

Mr. POWELL. Your "yes" applies to ordinary conditions?

Mr. LAFRENIERE. Yes, sir.

Mr. Powell. But for extraordinary conditions you would like a margin of safety in the shape of a provision for chlorination?

Mr. Lafreniere. Yes, sir. I have had some experience in the operation of both water and sewage treatment plants, and I know that operation end of it is often badly neglected and to a certain extent, I think, we have to provide for that, and we can not rely entirely on the work done by the municipality above to protect the municipality below. It might happen at times that improper operation of the sewage treatment plant might place an unreasonable burden on the filtration plant.

Mr. Powell. In view of the possibility of negligence or accident in the stream above, you would ask for a large margin of safety?

Mr. Lafreniere. I would not say a very large margin, but something to take care of such accidents.

Mr. Powell. Take question No. 10:

> Taking it for granted that it is impossible to control surface drainage from the countryside due to rain washings, etc., is it your opinion that modern efficient water-purification plants could adequately cope with this form of pollution?

Mr. Lafreniere. Yes, sir; I think that a modern efficient purification plant can take care of that pollution.

Mr. Powell. Question No. 11:

> Provided the discharge of urban sewage into any part of the Great Lakes or their connecting rivers is such that an unreasonable burden or responsibility is placed upon a water-purification plant, what methods of sewage treatment would you recommend to reduce the pollution to a point where no unreasonable burden or responsibility is placed upon such water-purification plant?

Mr. Lafreniere. I think that in the Great Lakes and their connecting rivers the dilution factor is large enough to prevent any nuisance. The point of importance is the bacterial pollution. Starting from that premise, I think that you would have to resort in most cases to chlorination or disinfection.

Mr. Powell. How about sedimentation and screening?

Mr. Lafreniere. I consider that sedimentation is almost necessary to obtain an efficient disinfection. Of course, I am simply considering the cost. If you disinfect the raw sewage you can obtain a high degree of efficiency by using so many parts of hypochlorite, and with clarified sewage less chemicals would need be used to obtain the same degree. I am not able to give any specific figures on that, but I believe that it is cheaper to settle the sewage before applying the chemicals. Most of the cities on the Great Lakes are sewered on the combined system, and in such cases it would be, I should think, almost necessary to use screens to remove most of the larger suspended matter, which would be troublesome in sedimentation tank, and also remove the nonfermentable matter in a grit chamber.

Mr. Powell. In addition to that, take the point of entrance of the sewage where this work of sedimentation and screening is going on; would you also have a degree of chlorination there?

Mr. Lafreniere. I would apply the chlorination at the outlet of the sedimentation tank. Of course, in certain cases, such as where the outfall is short, it might be a good practice to have a small basin there to retain the sewage for a certain time to give to the disinfectant its full effect.

Mr. POWELL. That would give it a better chance to produce its effect than if it were diluted afterwards?

Mr. LAFRENIERE. Yes; if it were diluted in a large body of water.

Mr. POWELL. In your judgment, would it be advisable for us to go farther afield and look for methods of purification other than sedimentation and screening?

Mr. LAFRENIERE. Such a matter has to be determined by the local conditions, and I may use this example: Suppose a large city has to purify its sewage just to protect the water supply or not to place an unreasonable burden upon the water purification plant of a much smaller community down below. It might be a better practice for the large city to supply good water to the smaller town instead of purifying its own sewage to protect it. That matter would be governed altogether by local conditions.

Mr. POWELL. Take question No. 12 now:

> Even if water purification plants properly constructed and efficiently operated existed in all municipalities, do you consider that indiscriminate discharge of sewage by vessels should be permitted?

Mr. LAFRENIERE. I did until I read the progress report.

Mr. POWELL. That gave you a new set of data?

Mr. LAFRENIERE. I never looked at it from the point of view that there was so much sewage from those boats, and still I should think that in most cases it would not be necessary for those boats to purify their sewage. However, I might cite the following case: On Saturday last, at noon, the city of Montreal wanted to try their emergency water intake, which is located in the Lachine Canal, and as the sanitary engineer for the board of health I recommended, and the board approved my recommendation, that orders be sent to the city of Montreal to enforce proper measures to prevent all the boats plying in the canal above the intake from discharging any sewage into the water of the canal. The Lachine Canal has a relatively small flow; but where you are in open waters it is very hard for me to consider it as a very serious question. It might be in certain cases, as the one I have just stated. For example, at Sault Ste. Marie, where you have a great many boats at one time——

The CHAIRMAN. Did your answer to the last question have any reference whatever to the steamboat population of the connecting rivers; that is, the rivers connecting the Great Lakes?

Mr. LAFRENIERE. Really, I would have to know more about the location of the water intakes and the channels traveled by the boats.

The CHAIRMAN. Take it in the Detroit River, for example. That is a comparatively narrow river. There are intakes there above Detroit and the other side of the line below Detroit, and in 1912 there was a steamer population of about 15,000,000. Most of that population passed up and down the Detroit River in a comparatively narrow channel. Do you not think that in that case some requirement by the two Governments should be imposed upon the owners of steamboats to treat their sewage on board, or also treat their water?

Mr. LAFRENIERE. Yes, sir; I do; especially if we consider that it would not be very expensive to treat the sewage to a certain extent before discharging it into the rivers or to dispose of it in some way at the docks.

The CHAIRMAN. They could also purify their water, could they not?

Mr. LAFRENIERE. Yes; they could not get good water at the ports or if they have not accommodations to carry the necessary supply of water between two docking points.

The CHAIRMAN. Then, in your judgment, should there be any international regulation with respect to water ballast of these large boats, both in connection with the taking of the water ballast and the discharging of that ballast? For example, the investigation of the first question of this reference shows that water ballast is taken in highly polluted areas and is discharged in perhaps less polluted areas in the vicinity of intakes of the different cities.

Mr. LAFRENIERE. If those highly polluted areas are to remain in that state, I should think that no water ballast should be taken from such area.

Mr. POWELL. Take Montreal, which presents a typical situation. Montreal draws its water supply from what source?

Mr. LAFRENIERE. From the St. Lawrence River.

Mr. POWELL. The St. Lawrence River receives its water from Lake Ontario, does it not?

Mr. LAFRENIERE. Yes.

Mr. POWELL. Are there many towns along that river?

Mr. LAFRENIERE. Yes.

Mr. POWELL. We, from Canada, might be more familiar with that situation than members of the commission from the United States.

Mr. LAFRENIERE. The cities of importance are Prescott and Brockville, and between Brockville and Cornwall are several small towns. I do not know exactly what their population is. There are also the cities of Valley Field and Beauharnois. There is the city of Lachine on the north side, but the sewage of that city is discharged below the intake of the city of Montreal.

Mr. POWELL. Then you have Ogdenburg on the United States side, and Kingston, Gananoque, Morrisburg, and then the Thousand Islands. Now, what is the condition of the water at Montreal intake? Is it unfit for domestic use in the condition in which it reaches that intake?

Mr. LAFRENIERE. Without any purification?

Mr. POWELL. Yes.

Mr. LAFRENIERE. Yes, sir.

Mr. POWELL. Is it badly contaminated?

Mr. LAFRENIERE. At times; yes.

Mr. POWELL. To what methods of purification do you resort?

Mr. LAFRENIERE. At present the water is treated with hypochlorite of lime pending the completion of the water filtration plant.

Mr. POWELL. But you are putting in a water-filtration plant in addition?

Mr. LAFRENIERE. Yes, sir. Mr. Fuller is the consulting engineer on that work.

Mr. MAGRATH. Where does Westmount get its water?

Mr. LAFRENIERE. It is supplied by a private company. That water is a mixture of the St. Lawrence River and the Ottawa River waters. That water is filtered by a mechanical filtration plant and treated after filtration with hypochlorite of lime. I must say that the city of Westmount did not register a single case of typhoid for the last three years.

Mr. POWELL. And, furthermore, it is a splendid water, is it not?

Mr. LAFRENIERE. Yes, sir.

Mr. POWELL. Is there the slightest taint in the water of the chloride? In drinking the Westmount water do you taste the chloride at all?

Mr. LAFRENIERE. I never did. I live in Westmount.

Mr. POWELL. Can you detect any smell in the Westmount water?

Mr. LAWRENCE. Not in the Westmount water, but I did in the city water. It is easy to explain why you can detect taste and smell in the city water. The St. Lawrence water is a surface water, and in the spring the river gets turbid. With any turbidity in the water a higher dose of chemicals is needed to obtain a good purification, and even then it is not always satisfactory.

Mr. POWELL. Then, in Montreal, thus far, they have depended altogether on chlorination, whereas in the case of Westmount chlorination is resorted to simply as an adjunct?

Mr. LAFRENIERE. The filtration plant in the city of Montreal has been under construction for over two years.

Mr. POWELL. But it is not completed?

Mr. LAFRENIERE. No, sir.

Mr. POWELL. So that the only reliance they had to depend on was chlorination?

Mr. LAFRENIERE. That is true.

Mr. POWELL. And, in the case of Montreal, it would take a much larger amount of chlorination than would be needed in Westmount?

Mr. LAFRENIERE. Yes, sir.

Mr. CASGRAIN. Have you anything to add to what you have already said, Mr. Lafreniere?

Mr. LAFRENIERE. No, sir; I do not think I have anything to add, thank you.

Mr. POWELL. Mr. Fuller and Mr. Phelps, in view of what has been said here since you gave the commission your views, would you wish to make any qualification or extension of the remarks you have already made?

Mr. WHIPPLE. I do not know that I have very much to say, except to bring out this idea: Reference has been made a number of times to the small number of B. coli in the waters of the middle of the lake, and some comparison has been made between such waters and filtered waters that have the same number of B. coli. I do not regard these two as being on a parity. I think that with the same number of B. coli in the raw water of the lake as in the filtered water the filtered water is the safer of the two. The filtered water is passed through the filtering mechanism, and it is surer of being safer at all times. Almost any filter plant will give a good water most of the time. When filter plants go wrong they usually go wrong for a short time each year. What we are after is a mechanism that will be at work every hour of the day. For the same reason I think it is safer to depend upon filtration than upon disinfection. We are quite sure that when the wtaer passes through a filter plant it will be at least partially purified at all times and well purified most of the time; whereas, in case anything happens to the mechanism used to apply the disinfectant, then the water goes without treatment for that time.

Several instances might be cited where that has actually occurred. One was right here in New York.

Perhaps I might be pardoned for saying a word in regard to Toronto. Mr. Dallyn spoke of the sand-filtration plant as not always giving satisfactory results. I do not think that is correct. It is true that from the time it was first put in operation the filter has been overloaded, yet the results have been good. It was designed for a smaller service, and the city grew so largely during the time of construction that it was overtaxed from the start. This made frequent cleaning of the sand necessary. If the commission has any doubt on this matter, I should be pleased to submit the records of operation during the time when my partner, Mr. Longley, was in charge of the operation of the plant.

After having listened to the testimony of the six engineers who have spoken, it seems to me that we are in substantial agreement all along the line. I fail to see any very great differences between us on any essential feature. That is to say, we are apparently all in favor, as an administrative proposition, of some form of sewage treatment, and we have in mind screening, sedimentation, and disinfection. Those are the three processes that seem to be the most useful along the border. I suppose we might differ in some particular instance of how far we might carry each one of these three, but I think we are all in general agreement as to the three processes. We are also in agreement in regard to the necessity of purification of surface waters. We might differ, perhaps, in the emphasis given to filtration and disinfection. Personally, I favor filtration rather than disinfection, but I believe that each is useful and has its place. I also believe that we should consider the disinfection of sewage as an additional factor of safety, and I think that the last speaker, perhaps, put that in a better way than any of us who preceded him. I do not think that I have anything further to offer.

Dr. STARKEY. Mr. Whipple, in view of the discussion about the load put on a filtration plant and the figures that were given by you and others, could you give any indication to the commission as to the figures on which you would base your calculation; that is, would you take the worst samples or an average of all the samples as your guide?

Mr. WHIPPLE. I think that we should have to depend upon an average condition, or, I might rather say, a median condition; that is the condition which ordinarily prevails. In almost any plant we are likely to get at times a sudden heavy load. Almost any filter plant will take care of that sudden heavy load. I think that Mr. Fuller had that in mind when he spoke of a standard of 500 B. coli per 100 c. c. Yesterday I gave the results of computations in which I used percentages of bacterial removal ranging from 97 to 99 per cent. We might well carry these calculations further. If so, we should find that with a percentage removal of 99½, to obtain a final result of 4 B. coli per 10 c. c. we should have to start with 800 B. coli per 100 c. c.; whereas if we had a removal of 99.75 it would be 1,600 B. coli per 100 c. c.; if 99.9 per cent, 4,000 per 100 c. c. It is not at all uncommon for filter plants to give these high percentage efficiencies. I do not think that it would be safe to count upon them at all times, day in and day out, but it is certain that filters will bear a much heavier load than 500 B. coli per 100 c. c. that Mr. Fuller referred to; that is, we should not take that as a maximum.

Our discussion has been largely confined to the bacteriological character of water to be filtered. This is because most of the boundary waters are relatively clear and colorless and the amount of organic matter small. In some cases the load on the filter ought to take this organic matter into account.

Mr. MAGRATH. I am not altogether clear as to your views regarding the mechanical filtration. To what extent can such plants be developed that they can be depended upon?

Mr. WHIPPLE. I think that they can be safely depended upon. There have been a great many improvements in the art of filtration in recent years, and especially in mechanical filtration. I think that the statistics of typhoid fever, as far as I have been able to learn, have shown substantially the same practical results where mechanical filters have been used as where sand filters have been used. I have recently had some occasion to study those figures, and I see no essential difference between the two systems where both systems have been well operated. It is not so much a question of the type of filtration as it is the size of the plant. Large plants generally receive better care than small plants. It is possible for sand filters to go wrong and it is possible for mechanical filters to go wrong, but where we have good operation we get good results from both types.

Mr. MAGRATH. It is possible for it to go wrong and not be detected for a sufficient time to do damage to health?

Mr. WHIPPLE. I suppose it is, and perhaps that danger is somewhat greater with mechanical filters than with sand filters. I would not hesitate to recommend to a city to install a mechanical filtration plant for the protection of its water supply. We have frequently done so and are continually doing so. The choice of the type of filtration depends upon the character of the water and upon other factors.

Mr. POWELL. These mechanical plants have grown enormously in public favor in the last 20 years, have they not?

Mr. WHIPPLE. They have.

Mr. POWELL. And the sand-filter plants have fallen in public favor?

Mr. WHIPPLE. I do not think that is wholly true.

Mr. POWELL. So far as adoption is concerned. I am not speaking about the real merits.

Mr. WHIPPLE. Yes; it is true that many more mechanical filtration plants have been introduced in recent years, but that is because the need for them has happened to come in those sections of the country where that type of filter is especially applicable. I think that that is likely to go on for some years to come. It is true also that this type of filter is better adapted to the larger proportion of the water supplies of the United States, but it would not be fair to say that there had been a retrogression in sand filters, for that would belie the experience of a very large part of the world, the European conditions especially.

Mr. POWELL. Mr. Fuller, have you any remarks to make?

Mr. FULLER. There are two points that have occurred to me. On the question of sewage treatment, the evidence, it seems to me, is pretty clear that some treatment is required. We all start out with the premise that water supplies should be subject to efficient purification, and, as Mr. Whipple has said, those plants should be not only well designed and well built, but also well operated.

It seems to me pretty clear that this evidence shows one fact, and that is that the filtration of sewage, one of the large elements of cost of sewage-treatment practice, is not required under any ordinary circumstances, and, perhaps, under no circumstances at all, in connection with the sewage-disposal problems along the boundary waters. Those two points, I think, are very conspicuous.

Now, coming to what I had more particularly in mind when I arose, there are two factors of sewage treatment, one the question of clarification and the other the question of sterilization. There has been a good deal said here about screening, and, perhaps, it has not been made clear that there is now coming into use in this country fine screens down to perhaps one-twelfth of an inch for size of opening whereby we could get substantially complete clarification, as far as the removal of ordinary suspended matter is concerned. I believe that independent of sterilization the question of fine screening as against sedimentation should be placed in the nature of options to the local authorities. We have had a good deal of difficulty around the water front of New York City in getting sites whereby we could install suitable sedimentation devices. I am having in mind now the use of these wide streets, building tanks under them, and things of that sort; but they are complicated by questions of quicksand on the lower portion of this island, and, I believe, it would be unwise to try and draw too close lines as between fine screening and sedimentation.

With regard to sterilization or disinfection, my mind is not quite clear on these aspects. I realize the desirability of having sewage treated in substantially the same way by all municipalities involved. It is a question of policy that will have to be considered with much care as to whether uniformity of treatment should be the ruling of this commission or whether the different municipalities should have the benefit of the inherent right which may be theirs by virtue of their location. Some cities like New York do not have to pump all of their water supply. There are others that do have to pump their entire water supply. There are some cities where they have to pump their sewage in order to get it into the river, like New Orleans. In my experience I have had this thought frequently accentuated: That there are certain locations which carry with them inherent rights, and it may perhaps come up to you, gentlemen, to say whether you want to have a uniform law or a uniform prescription as to minimum sewage treatment. I am not trying to answer that question, but I know that it is a problem that has much practical significance.

There is one other point accentuated by Mr. Whipple to which I subscribe myself fully, and that is the impossibility with the great run of our American and Canadian cities, equipped with a common or single pipe sewerage system to cope fully with the sanitary situation in dealing with storm overflows; that is, where you are carrying off the storm water in the same sewer lines that are carrying off the household drainage, and when you have heavy rainfalls there is going to be a greater flow than can be handled with any ordinary sewage treatment device. I am speaking now of the sterilization of storm flows. Even that probably is a cheaper thing to do than to follow the other suggestion made here of putting down a new system of sewers which will take care of the household waste and let the existing sewers be devoted to rain water. Mr. Dallyn said that in Chicago they had spent to date about $15 per capita on the sewerage systems, but those sewers were laid down at a time when there were comparatively few pavements in the city and when there were practically no obstructions underneath the surface of the ground, as there are to-day in the loop district. I am speaking now of the multiplicity of telephone conduits, steam-heating lines, and the trolley connections at the surface, and there are also some tunnels, although not like our subways of New York City; but there are a great many elements of cost there to be encountered now that were not met with in the early days of sewerage construction at Chicago.

My estimate, as I recall it, amounted to something like $25 per capita for a new system of sanitary sewers to take care of the household wastes of that city. Mr. Whipple jogs my memory on one point; that is the cost of shifting the plumbing connections within the house and of building a new line out to the city sewer. These cost, I believe, on an average more than $10 per connection.

The point of option to be given to the local authorities as between the fine screening and sedimentation is a point that I believe has a good deal of significance. That and the question of the advantage that may or not be taken by a municipality on account of its location and the question of storm overflows are the principal points I desire to mention.

Mr. Powell. As a matter of fact, Mr. Fuller, I suppose the question of storm overflow is a much more important consideration in flat cities than in what we might call hilly cities?

Mr. Fuller. No; I think it is the other way around. In these precipitous cities rainfall runs off much more rapidly, and it would punish the sewage-treatment plant much more.

Mr. Powell. In St. John they all enter one sewer?

Mr. Fuller. Yes; but it is largely a function of the time involved in the collection and in the peak load, so to speak, that would reach the outfall or treatment works; and the added burden is directly proportional to the intensive or extraordinarily high volumes of flow which come at certain times.

There has been discussed a great deal here in New York the question of whether or not it would be feasible to get these harbor waters in such shape that public baths could be used. All of the evidence is to the effect that it is practically impossible to control storm flows here adequately, and it has resulted in the policy, as I understand it, of seeing that the different public baths here are to be equipped with purified water.

With regard to the pollution by vessels along these watercourses, I believe the water supply on board these vessels should be made at all times of a purity above suspicion. Whether that should be done by getting it at docking points or whether it should be done by getting distilling or other treatment apparatus on board vessels would depend somewhat on various local factors. Treatment of the sewage coming from the vessels, I also think, is desirable. With regard to how practicable it would be, I do not know of any evidence that would now lead me specifically to a satisfactory conclusion. It is worth trying.

Mr. **Dallyn.** I think, Mr. Fuller took an advantage of my testimony with regard to storm overflows.

Mr. **Fuller.** Not intentionally, sir.

Mr. **Dallyn.** I recognize that. Mr. Fuller is discussing existing conditions, while the commission is discussing a problem as to future development, as I was also. As to future development, it is a large question, when treatment is involved, whether the storm overflows in the sanitary sewers could be separated. Mr. Fuller has discussed rectifying existing conditions, and we all know that that is a very expensive matter. These municipalities are increasing in size every year.

Mr. **Fuller.** On the question of storm sewers and separate pipes for handling household waste and the flow of all rainwater; I think it is absolutely certain that Mr. Dallyn is right—that in all future developments and in all new communities starting in with new sewerage systems they should keep the household wastes in separate pipe lines. It ought to be done in the interest of the taxpayers.

The **Chairman.** Gentlemen, on behalf of the commission, I wish to express to you our gratitude for your coming before us voluntarily and giving us the benefit of your experience and judgment in respect to the subject matter that we have under consideration by reference of both Governments. We appreciate it very much and thank you for what you have done.

(The commission thereupon, at 1.15 o'clock p. m., took a recess until 2 o'clock p. m.)

AFTER RECESS.

STATEMENT OF SURGEON ALLAN J. McLAUGHLIN,[1] UNITED STATES PUBLIC HEALTH SERVICE.

What is a Safe Drinking Water?

Cities using sewage-polluted water without purification invariably have very high typhoid-fever rates. The installation of a filtration plant to purify the polluted water supply almost without exception effects a prompt and remarkable reduction in the typhoid-fever rate. This reduction is usually so great that municipal officials are satisfied that their water supply is perfect, when in reality there is still something to be desired. When a city with typhoid-fever rates consistently above 100 deaths per 100,000 population has a reduction coincident with the installation of a filtration plant to a rate between 20 and 30, there is good ground for general rejoicing because of the undeniable saving of human lives. Nevertheless, the raw water may be of such a character that an unreasonable burden is imposed on the filtration plant, and under such circumstances, in spite of fair efficiency, the plant delivers an effluent which is unsafe at times.

With the general sanitary conditions which pertain in American cities and a safe public water supply, there is no valid excuse for typhoid rates above 20 deaths per 100,000 population. There is excellent evidence to show that if all the water-borne typhoid were eliminated in northern cities the rate for typhoid fever would be less than 10. As a matter of fact, there is a group of American cities which is fast approaching European cities in the matter of low typhoid-fever rates. These are the cities which have gone farthest in making their water supply safe, and while their yearly typhoid-fever rates are not always expressed in a single figure, their rates are usually below 12. In these cities with safe water supplies the general sanitary conditions, exclusive of water supply, are not conspicuously better and in some instances are very much worse than those found in cities with polluted water supplies and high typhoid-fever rates.

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[1] Chief sanitary expert and director of field work, International Joint Commission.

There is a large group of cities in which, following the substitution of a filtered for a polluted public water supply, the rates have been greatly reduced but still remain too high. These cities should not be satisfied with typhoid-fever rates of from 15 to 30, but it behooves them to make a searching investigation to determine whether the raw water imposes an unreasonable burden on their filtration plant, or if their plant is efficiently operated and delivering a safe water at all times. This brings us to the question of

WHAT IS SAFE DRINKING WATER?

In order to say that a drinking water is hygienically safe one must be assured that it contains no pathogenic bacteria. The efficiency of water-purification plants varies from day to day and from hour to hour, and an opinion upon the absolute safety of a given water supply can not be rendered unless many bacteriologic analyses, made at short intervals during each 24 hours, show an absence of B. coli. While an absolute dictum is thus most difficult to secure, it is not difficult by daily bacteriologic analysis to determine that a water does or does not give a reasonable index of safety. Instead of attempting to find the germs of typhoid fever, Asiatic cholera, and dysentery in water, we accept the presence of B. coli as an index of pollution with sewage, for the reason that the chances of finding B. coli are very much better than the chances of finding the specific germs in the small quantity of water examined.

When we consider the grossly polluted water supplies used by many of our large cities until recent years, we must admit that even if the present effluents from filter plants do not show constant absence of B. coli, still they must be classed as reasonably safe, or relatively safe water.

In order to secure statistics from some of our largest filtration and purification plants a circular letter was sent out to about 40 cities. About 15 responded, and in most instances the statistics covered at least one year. The list included mechanical or "rapid" sand filtration, slow sand filtration, precipitation and disinfection, and disinfection alone.

Table 1 shows the average number of B. coli per 100 c. c. in both raw water and filtered or treated water.

TABLE 1.

City.	Number of samples.	Type of filtration.	B. coli per 100 c. c. of—	
			Raw water.	Filtered or treated water.
Toledo, Ohio	342	Mechanical filtration.	804	0.02
Minneapolis, Minn	418	do	75	.1
Grand Rapids, Mich	365	do	92	.3
Birmingham, Ala	205	do	196	1.0
	174	do	400	.2
Cincinnati, Ohio	240	do	1,175	1.4
Binghamton, N. Y	420	do	59	1.2
Columbus, Ohio	365	do	606	1.3
Washington, D. C	348	Slow sand	2,501	1.4
Providence, R. I	600	do	732	4.3
Reading, Pa	138	do	68	5.8
Baltimore, Md	306	Alum and hypochlorite.	1,349	2.5
Richmond, Va	237	do	460	8.0

Some of the results are of special interest, and the statistics for these cities are presented by months.

Toledo, Ohio.—The Toledo plant is of the mechanical-gravity type. Hypochlorite is applied to the raw water before sedimentation in quantities of 15 to 30 pounds per 1,000,000 gallons. Then aluminum sulphate is used as a coagulant.

Table 2 shows the results by months in Toledo.

The Toledo plant, by the use of heroic doses of hypochlorite, is able to convert a bad raw water into a safe effluent, but in spite of this fact the necessity for constant efficiency in treating such a raw water every hour in every day from January to June places an unreasonable responsibility on the plant. From June to October a fair raw water is furnished. In November and December the B. coli per 100 c. c. in raw water was again too high.

TABLE 2.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of—		Season.	Number of days' samples.	Average B. coli per 100 c. c. of—	
		Raw water.	Filtered water.			Raw water.	Filtered water.
1913.				1914.			
January	25	1,848	0	March	31	1,000	0
February	26	145	0				
March	26	2,238	.3	January, 1913, to March, 1914	342	804	.029
April	30	1,105	0				
May	29	1,270	0				
June	28	67	0				
July	27	300	0				
August	11	600	0				
September	30	280	0				
October	29	286	0				
November	27	766	0				
December	23	530	0				

Minneapolis, Minn.—Excellent results are also obtained in Minneapolis by a mechanical or rapid sand filtration plant. Minneapolis differs from Toledo in that the hypochlorite is applied to the filtered water and not to the raw water in quantities of three-tenths to four-tenths parts per million available chlorine. The raw water at Minneapolis is very much better than that of Toledo.

Table 3 gives the average number of B. coli per 100 c. c. in both raw and filtered water by months in Minneapolis.

TABLE 3.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of		Season.	Number of days' samples.	Average B. coli per 100 c. c. of	
		Raw water.	Filtered water.			Raw water.	Filtered water.
1913.				1914.			
February	26	23	0.7	January	30	100	0
March	31	39	0	February	28	90	.3
April	30	8	.3	March	31	242	.6
May	29	44	0	February, 1913, to March, 1914	418	75	.19
June	30	25	0				
July	31	73	0				
August	31	85	.6				
September	30	79	0				
October	31	53	0				
November	30	85	0				
December	30	100	0				

Cincinnati, Ohio.—The Cincinnati plant utilizes plain sedimentation followed by coagulation and mechanical filtration. Sulphate of iron and caustic lime are used, the latter to assist the action of the iron sulphate and not for softening purposes. Hypochlorite is added to the filtered water for about five months in the year. About 1 pound is used to each millon gallons of water. Hypochlorite is used during January, February, March, April, and May, which covers the period of muddy water and high bacterial counts.

TABLE 4.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of		
		Raw water.	Filtered water without "hypo."	With "hypo."
1913.				
September	28	964	2.1	....
October	31	358	1.5	....
November	30	1,990	2.7	....
December	31	1,841	3.0	....
1914.				
January	31	1,232	9.1	0.6
February	28	1,260	3.5	1.2
March	31	825	2.4	.06
April	30	933	20.0	.4
September, 1913, to April, 1914	240	1,175	5.6	1.4

The results are very interesting. A bad raw water which threatens to overtax the purifying capacity of the filters is successfully handled by the use of hypochlorite as an auxiliary. The results shown in Table 4 indicate that in January, February, March, and especially April, 1914, the plant without the aid of "hypo" was unable to successfully cope with the bad raw water. With the aid of "hypo" a good effluent was secured.

Columbus, Ohio.—At the mechanical filtration plant of Columbus, Ohio, lime, soda ash, and aluminum sulphate are used. Hypochlorite is occasionally used applied to the settled water before filtration. Table 5 gives results by months for the year 1913. With a bad raw water excellent results are obtained. Mr. Hoover, the chemist in charge, attributes these results to the free use of lime. This seems probable, as very little hypochlorite is used.

TABLE 5.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of—		Season.	Number of days' samples.	Average B. coli per 100 c. c. of—	
		Raw water.	Filtered water.			Raw water.	Filtered water.
1913.				1913—Continued.			
January	31	3,462	1.6	September	30	294	0.3
February	28	272	1.0	October	31	131	1.2
March	31	782	0	November	30	178	1.3
April	30	931	2.3	December	31	33	.3
May	31	196	1.9				
June	30	283	0	January to December	365	606	1.3
July	31	378	5.1				
August	31	277	.6				

Washington, D. C.—Washington, D. C., has a slow sand filtration plant. There is large reservoir capacity and some alum is used in times of high turbidity. No hypochlorite or chlorine is used at any time. The general average for the Washington plant for 348 samples shows 1.4 B. coli per 100 c. c., which must be classed as very good effluent. A close study of the results for individual months shows that there is great fluctuation in the character of the raw water. There was a very bad raw water in January, 1913, and April, 1913, and the results show that this unreasonable burden was probably too much for the purifying capacity of the plant. Table 5 shows the results of filtration in Washington, D. C., by months:

TABLE 5.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of—		Season.	Number of days' samples.	Average B. coli per 100 c. c. of—	
		Raw water.	Filtered water.			Raw water.	Filtered water.
1913.				1914.			
January	25	4,582	7.4	January	25	640	0
February	23	592	1.0	February	23	211	.5
March	25	2,871	.5				
April	26	20,910	4.1	January, 1913, to February, 1914	348	2,501	1.4
May	26	661	0				
June	25	910	0				
July	26	5	0				
August	24	88	0				
September	25	412	.5				
October	27	622	4.7				
November	23	1,167	.5				
December	25	538	.5				

Birmingham, Ala.—The water supply for Birmingham is derived from two separate sources, as follows:

(*a*) Five Mile Creek, which is a stream to the north of the city, having a minimum flow of four and one-half million gallons, with a watershed area of 16.1 square miles and a population density of 31.9 per square mile. Five million gallons daily is supplied from this stream except during the dryest seasons. The waters of Five Mile Creek are diverted at a point 6 miles from the city and brought by gravity through a closed conduit to the North Birmingham purification plant, which consists of sedimentation basins and rapid sand filters of 5,000,000 gallons nominal capacity and sterilization by hypochlorite. The analysis marked "North Birmingham" shows the raw and the treated water of this supply during the year 1913.

(*b*) Cahaba River: The watersheds of Cahaba River lie to the east of Birmingham. The west prong or Big Cahaba furnishes the supply, except when its minimum flow is less than the daily pumpage, in which case the East Cahaba is drawn upon by means of a small diversion dam below the junction of the two rivers. To supplement the dry-weather flow, a dam has been built on the east fork, or Little Cahaba, and a large impounding reservoir of 1,250,000 gallons created, known as Lake Purdy. The total watershed area is 205 square miles. The area above Lake Purdy is 49.7 square miles. The density of population on the entire shed is estimated at about 20 per square mile.

The pumping station on the Big Cahaba, 2 miles above the diversion dam at the junction of the two forks, forces the water to a purification plant on Shades Mountain. The purification plant consists of two large sedimentation reservoirs, holding 118,000,000 and 28,000,000 gallons, from which the water flows by gravity through a rapid sand filtration plant, having a present nominal capacity of 19,000,000 gallons daily, with eight additional million under construction. The filters discharge into a clear-water basin of 3,000,000 gallons capacity, from which the water flows by gravity to the city, a distance of 4 miles.

CAHABA PLANT.

[No chlorination.]

Season.	Number of days' samples.	Average B. coli per 100 c. c. of—		Season.	Number of days' samples.	Average B. coli per 100 c. c. of—	
		Raw water.	Filtered water.			Raw water.	Filtered water.
1913.				1913.			
Jan. 1-Feb. 28	35	305	0.28	July 23-Oct. 20	35	112	1.4
Mar. 1-Apr. 10	35	105	.56	Oct. 22-Nov. 28	16	23	0.0
Apr. 11-May 21	35	87	.00	Dec. 1-Dec. 30	14	323	4.2
May 22-July 21	35	208	2.28	Jan. 1-Dec. 31	206	196	1.0

NORTH BIRMINGHAM PLANT.

[With chlorination.]

Season.	Number of days' samples.	Raw water.	Filtered water.	Season.	Number of days' samples.	Raw water.	Filtered water.
1913.				1913.			
Jan. 1-Feb. 6	31	700	0.3	Sept. 15-Nov. 3	34	288	0.0
June 9-July 25	33	800	.6	Nov. 4-Dec. 31	41	240	.0
July 28-Sept. 12	35	1,337	.3	Jan. 1-Dec. 31	174	400	.2

The two Birmingham plants furnish very interesting data also on the value of hypochlorite as an aid in handling a bad raw water. The Cahaba plant uses no hypochlorite. In December, 1913, raw water, with an average of 323 B. coli per 100 cubic centimeters, seemed to overtax the purifying capacity of the plant. A load of 204 B. coli per 100 cubic centimeters in June and July seemed to be about the limit that the plant could care for, although in the period from January 1 to April 10 an average of 305 in the raw water was reduced to less than 1 B. coli per 100 cubic centimeters in the effluent. The North Birmingham plant had a worse raw water to deal with. This plant uses hypochlorite as an adjuvant. The average for raw water of 700, 800, and 1,337 B. coli per 100 cubic centimeters was reduced to less than 1 B. coli per 100 cubic centimeters in the effluent. From September to December, with a fair raw water averaging 240 and 288 B. coli per 100 cubic centimeters, a perfect result was obtained with entire absence of B. coli in the 71 samples.

Following a sanitary survey of the cities and towns in the basin of the Great Lakes, the writer recommended, among other things necessary, that a standard for filtered or treated water be established which should be a minimum requirement for the prevention of the spread of water-borne disease in interstate traffic. The Surgeon General of the Public Health Service appointed a commission in January, 1913, to fix such a standard. The report of this commission will be published soon. The majority of the members favored a standard of four negatives out of five 10-cubic-centimeter tests for B. coli. The writer expressed this standard in a different way, recommending a standard of not more than 2 B. coli per 100 cubic centimeters of water, taking the average of many samples by Phelps's method.

Allowing a sufficient margin of safety, filter plants with a decent raw water should produce effluents of less than 2 B. coli per 100 cubic centimeters, and it is the opinion of the writer that a modern water-purification plant which delivers an effluent which has more than 2 B. coli per 100 cubic centimeters is either inefficiently operated or is dealing with a raw water which imposes an unreasonable burden upon the plant. Accepting tentatively the standard of less than 2 B. coli per 100 cubic centimeters as a good drinking water, although not perhaps an ideal drinking water or a safe drinking water at all times, the results indicate that this standard is attained by both "rapid" sand and slow sand plants, even with a very bad raw water. Cincinnati and Washington, D. C., are good examples of each type. Close examination of the daily records at Washington and Cincinnati show that while this excellent average is attained for the year, there are periods when the capacity for purification seems to be overtaxed by the very bad raw water. At Cincinnati the use of hypochlorite seems to compensate for the deficiency in purification by the standard process, but in Washington the excellent general average of 1.4 is only attained by the almost perfect purification effected during periods when the raw water is fairly good.

There is a strong tendency in America to accept any raw water, however bad, as a source for a municipal filtration plant. This often imposes an unreasonable burden and responsibility upon the water-purification plant. Now, filter plants are not infallible. They are mechanisms which must be properly constructed and efficiently operated under careful bacteriologic control in order to secure a safe effluent. They are operated by human agency and subject to the results of human error. It is true that properly constructed and efficiently operated filter plants can produce safe water from a very bad raw water, especially by the use of hypochlorite or liquid chlorine as an adjuvant. The responsibility of effecting such purification every hour of every day in the year is unreasonable and unfair. Many plants are now struggling with a raw water of such a character that a safe effluent is only obtained at the price of eternal vigilance, perfect operation every day in the year, and the free use of auxiliary chemicals. The raw water demanding such extraordinary treatment is, like a sword of Damocles, constantly threatening disaster. There is no margin of safety under such conditions.

I believe that a sufficient margin of safety should be given to all filter plants by reducing the pollution of the raw water to a point where it would not impose an unreasonable burden or responsibility upon the plant. I believe that in reckoning the bacterial purifying capacities of filtration plants hypochlorite or liquid chlorine should not be considered, but that a raw water should be furnished of such a character that the plant could turn out constantly a safe effluent without the aid of chlorine. This would reserve the chlorination as an additional margin of safety for use in extraordinary fluctuations of the raw water or during accidents to the plant or interruptions in its ordinary efficiency.

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